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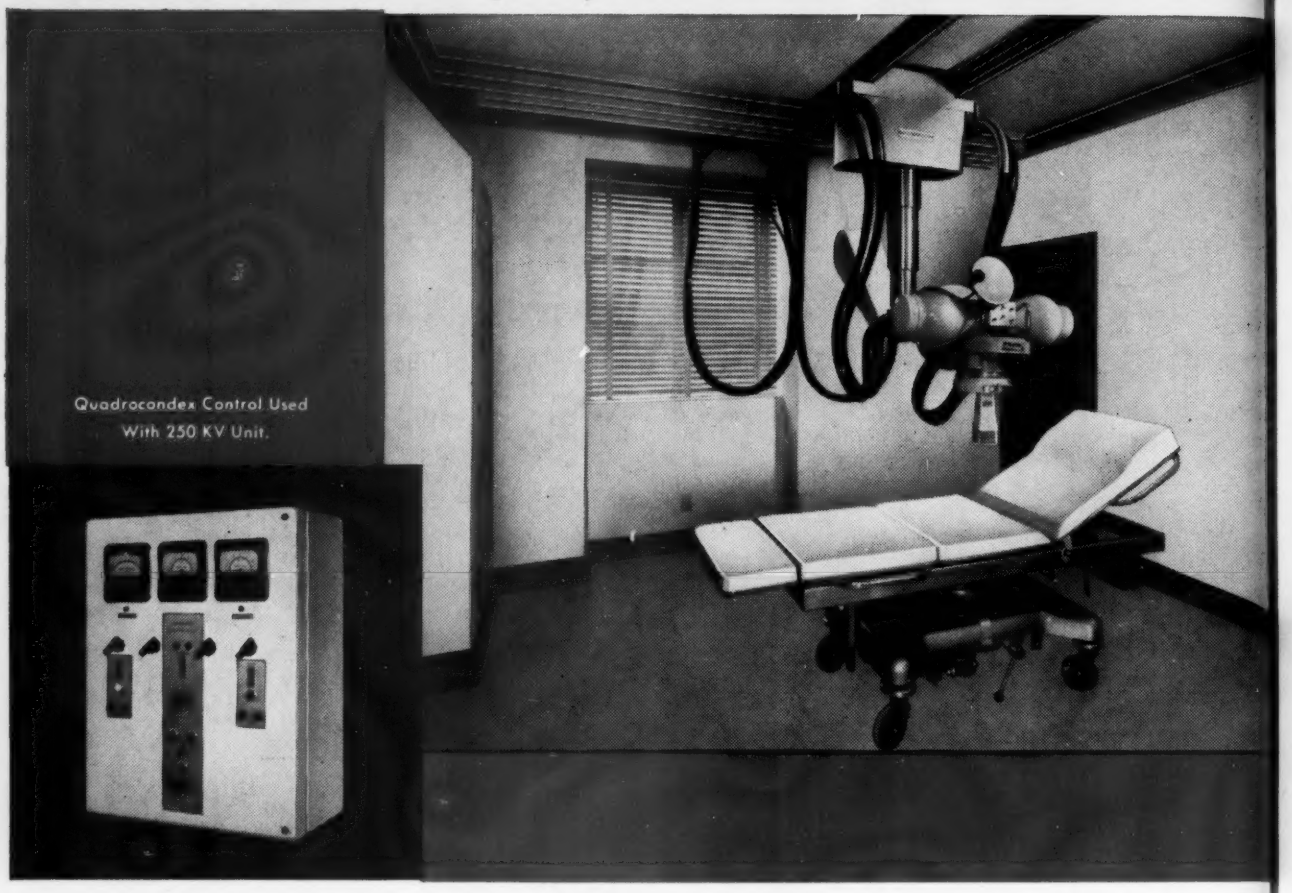

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VOL. 74 JULY, 1955 NO. 1

CONTENTS

Cervical Air Myelography; A Review of 130 Cases. F. MURTAGH, M.D., W. E. CHAMBERLAIN, M.D., M. SCOTT, M.D., AND H. T. WYCIS, M.D. . 1

Gallstone Obturation; Clinical and Roentgenographic Considerations. LEO S. FIGIEL, M.D., STEVEN J. FIGIEL, M.D., FRED K. WIETERSEN, M.D., AND EDWARD J. DRANGINIS, M.D. 22

Endocardial Fibroelastosis. ELMER G. ST. JOHN, M.D., AND THOMAS A. COPE, JR., M.D. 39

Osteopetrosis in Adults. C. L. HINKEL, M.D., MED.SC.D., AND D. D. BEILER, M.D. 46

Osteoid Osteoma of the Femoral Neck; Report of Three Cases. GEORGE F. JOHNSON, M.D. 65

Roentgen Kymography of the Diaphragm. BERNARD S. EPSTEIN, M.D. . 70

Fibrin Body Following Traumatic Pneumothorax; A Problem in Differential Diagnosis of a Nodular Pulmonary Density. EDWIN J. EUPHRAT, M.D., AND ERWIN BECK, M.D. 86

The Mode of Action of Thorium X on Human Skin. VICTOR H. WITTEN, M.D., AND MARION B. SULZBERGER, M.D. 90

Professional and Administrative Indexing System. DAVID M. GOULD, M.D., AND RUSSELL H. MORGAN, M.D. 98

Radiation Dosimetry in the Treatment of Carcinoma of the Cervix Uteri by Intraparametrial Radioactive Gold and Radium. MICHEL TER-POGOSSIAN, PH.D., AND ALFRED I. SHERMAN, M.D. 116

Combination Parenteral Aureomycin and Irradiation in Far-Advanced Cancer. JEANNE C. BATEMAN, CHARLOTTE P. DONLAN, CALVIN T. KLOPP, AND J. KEITH CROMER. 123

Reduction of Life Span of Rats by Roentgen Irradiation. J. B. HURSH, T. R. NOONAN, G. CASARETT, AND F. VAN SLYKE 130

The Lethal Dose of Total Body Cobalt-60 Gamma Radiation for the Rabbit. JOHN H. RUST, D.V.M., GLENN D. FOLMAR, JR., M.S., J. J. LANE, B.S., AND BERNARD F. TRUM, D.V.M. 135

(Contents continued on p. iv)

Editorials

The Annual Meeting of the American Roentgen Ray Society . . . 140

William Roland Bethea, 1880–1954. John W. Evans, M.D. . . 142

Society Proceedings, Correspondence and News Items 144

Book Reviews 153

Books Received 155

Abstracts of Radiological Literature 157

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THE AMERICAN JOURNAL OF ROENTGENOLOGY
RADIUM THERAPY AND NUCLEAR MEDICINE

VOL. 74 JULY, 1955 No. 1

CERVICAL AIR MYELOGRAPHY

A REVIEW OF 130 CASES

By F. MURTAGH, M.D., W. E. CHAMBERLAIN, M.D., M. SCOTT, M.D., *and* H. T. WYCIS, M.D.

From the Departments of Neurosurgery and Radiology, Temple University Medical School and Hospital

PHILADELPHIA, PENNSYLVANIA

NEGATIVE contrast myelography, with air or oxygen, has not been widely used, largely because of the difficulty encountered in interpretation, and the dramatic demonstrations which can be obtained with the positive contrast agents. The fact remains, however, that air and other gaseous media, at this writing, are still the only innocuous and completely absorbable contrast media which do not require removal at the completion of the examination. With the use of the techniques to be described, it is our feeling that air myelography has a definite diagnostic value, certainly not as a substitute for opaque media, when such are indicated, but as an effective and harmless method of surveying the suspected portion of the canal, which may often be sufficient for accurate localization and in some instances capable of demonstrating types of involvement of the spinal cord which cannot be seen with positive contrast.

Dandy,[9] while examining his early pneumoencephalographic films in 1918, observed in some of the views the upper portion of the cervical cord outlined by air and suggested at this time that it might be possible to use air to visualize tumors in the spinal canal. At about the same time, Wideröe[21] was working with air as a contrast medium and in 1921 reported a case of tumor in the cervical spine localized by intraspinal air injection and proved by surgery. It is interesting to note that he did not visualize the air in the canal and felt it hardly probable that anyone would ever succeed in doing so, but based his localization on the root pains the patient experienced as the air passed the narrowed canal. It was his opinion that the clinical symptoms which appear during and after the air injection would be decisive for localization purposes.

In 1922, Dandy[10] mentioned 5 cases of suspected spinal cord tumor in which small amounts of air had been injected into the lumbar canal and the patient placed upright to determine the presence or absence of block in the canal. In 4 of the cases the air immediately ascended into the head, as evidenced by the patient's painful reaction and the roentgenographic demonstration of air in the ventricles. He concluded that inasmuch as no block could be demonstrated, a lesion did not exist in the canal

and searched elsewhere. One case exhibited a complete block at the upper levels of of C5. This patient received antiluetic therapy with relief of symptoms and, in a follow-up study, all the air passed into the head, thereby demonstrating relief of the block. Later, in 1925 Dandy[11] reported 10 spinal cord tumors in 7 of which he was able to accurately demonstrate the lower level of the lesions which were completely blocking the spinal canal. The remaining 3 cases had lesions completely blocking the canal at the level of the needle puncture. He suggested that in lesions below L2, retrograde myelography could be done by making the puncture in the cisterna magna and placing the patient in the Trendelenburg position. Dandy's conclusions were that while air gave less detail, it was quickly absorbed from the spinal canal, and its greatest use lay in its ability to demonstrate the presence or absence of tumor, in suspected cases, by verifying the presence or absence of a complete block. In those cases where tumor could be demonstrated by air, correlation with the neurologic findings was usually adequate to accurately localize the level of the lesion. He felt very strongly that air was completely unsatisfactory for use in the cervical spine because of the large tracheal air shadow superimposed upon that of the spinal canal in the anteroposterior projections.

It was the general feeling at this time among those using air for myelography that the method had little to offer because of the poor contrast but it must be remembered that the roentgenographic technique of that era could not produce the detail and excellent contrast that we see today.

Coggeshall and von Storch,[7] in 1934, reported visualization of the lumbocaudal sac in 3 cases. At that time Van Wagenen[20] reported 3 cases of spinal cord tumor in which he was able to accurately demonstrate the lower level of the lesion by injecting small amounts of air into the blocked spinal canal.

Scott and Young,[17] in 1937, were the first to demonstrate the visualization of a herniated disc by air myelography. Ten cases of spinal cord lesion were reported, all surgically verified as having been accurately localized by air. They restated Dandy's recommendation that, in the absence of a block, the entire spinal canal should be filled in a retrograde manner through a cisternal tap with the patient in the Trendelenburg position.

Simultaneously, Sherwood and Behrens,[18] in their discussion on herniated discs, advocated the use of air myelography and recommended the use of oil only if the air myelogram was questionable. They, however, cited no specific cases.

In 1938, Young and Scott[23] expanded their cases to 13 verified lesions and recommended the use of oil only if the air myelogram was negative and clinical signs persisted.

In 1939, Chamberlain and Young,[4,5] who had been using air routinely since 1936, reported on their experience with negative contrast in 300 cases. They felt that the method was accurate and gave no false positives, inasmuch as all positives that had been verified by laminectomy had proved to be correct. They pointed out that the herniated disc nearly always carries the posterior longitudinal ligament dorsad so that the encroachment on the ventral aspect of the air column is usually detected best in the lateral projection. Retrograde drainage of the lumbocaudal sac with the patient in the Trendelenburg position was recommended for visualization of lesions below L3, and complete drainage of the cerebrospinal canal was advocated in instances when no block was present and where the lesion was suspected in the dorsal or cervical spine. The need for films of the best contrast and detail was emphasized as necessary for satisfactory interpretation. It was their opinion that air, being innocuous and completely absorbable, could be more frequently used and the benefit of myelographic studies not limited only to those with positive neurologic findings.

Reichert[16] at the same time reported on

his experience with 35 cases, 25 per cent of which were negative and 50 per cent of the positives were confirmed with lipiodol. He concluded that satisfactory visualization could be obtained with air, particularly with disc herniations and recommended using oil only in those cases where the presence of a lesion had been proved by air, but where more accurate localization was needed. Lindgren,[13] also in 1939, advocated the use of air in myelography, pointed out that with negative contrast it is possible to visualize the cord itself and felt that, with the proper technique, it was as reliable as oil in the lumbocaudal sac.

Reports on the use of air are sporadic after this period and consist mostly of discussions of variation in technique. Busch,[2] in 1941, recommended injection of air into the subarachnoid space until a positive pressure of 250–300 mm. of water was reached. Munro and Elkins[14] favored the two-needle technique. Galbraith,[12] whose cases were limited to examinations of the lumbosacral canal for disc herniation, advocated the use of 10 cc. of air in addition to the amount of air equal to the quantity of spinal fluid withdrawn. Olsson,[15] in 1948, felt that the iodized oils were too viscid to completely fill the root pockets. He placed his patient in the lateral recumbent position with the healthy side down, and after withdrawing 30–40 cc. of spinal fluid, injected air until a pressure of 300–400 mm. of water was obtained. The patient's sciatic pain was usually reproduced and roentgenograms taken in this position revealed the root pockets to be well filled.

Camp, in 1949,[3] recommended the use of air in the study of the lumbar canal and for the recognition of herniated lumbar intervertebral discs, provided the examiner was fortified with enough experience and confidence to interpret the results. This fact seems well established among those using air frequently and employing a careful, rigid technique.

The cervical spinal canal and cord, especially at the level of the foramen magnum and first cervical vertebra, are particularly difficult to visualize adequately, even with positive contrast media, specifically in the absence of a lesion blocking the canal.

This report represents a survey of 142 individual air myelographic studies which were made on 130 patients at Temple University Hospital, during the period from 1934 to 1949. All patients had symptoms suggesting cervical spine or cord abnormality. However, the examinations were not limited to those exhibiting positive neurologic signs.

METHODS OF EXAMINATION

Studies Made with Small Quantities of Air. Twenty-four studies in this series were made as originally prescribed by the early investigators in cervical air myelography.

The patient was placed in the lateral recumbent position on a stretcher, the lumbar puncture made in the third or fourth interspace, a Queckenstedt test performed and 5 to 10 cc. of spinal fluid removed and replaced with an equal amount of air. The patient was then placed in the upright position before a Potter-Bucky diaphragm. The clinical reactions of the patient were studied carefully at this time. If the patient immediately complained of severe headache it was assumed that a block was probably not present in the cervical canal and that the air had passed immediately into the cranial cavity. If the patient did not exhibit symptoms of headache after having been placed in the upright position it was felt that a block did exist in the cervical canal, which was confining the air to the area below the level of blocking. If the patient complained of local pain in the neck area as orginally described by Wideröe, this was felt to be further corroborative evidence of the presence of a lesion. Stereoscopic films of the cervical spine were then taken in this position in the anteroposterior projection, the lateral projection and both oblique projections.

In 17 of these 24 studies, the lower level

of a complete or nearly complete block in the cervical spinal canal was successfully demonstrated. Fifteen of these patients were operated upon and the level of the lesion proved to be as visualized in the myelogram. The 2 additional patients were not operated upon.

In 7 of the 24 studies the air passed immediately into the cranial cavity when the patient was placed in the upright position. Films taken of the skull demonstrated the presence of air in the cranium; however, no air was visualized on any of the films taken of the cervical spine. These studies then, while they clearly demonstrated the absence of a lesion blocking the cervical spinal canal, were of no value as a contrast study of this area to determine the presence of a lesion which was not blocking the canal.

It was the original concept that if the absence of a block in the cervical spinal canal could be demonstrated by this method, it was reasonably conclusive evidence that a space-taking lesion did not exist in this area and the diagnostic search was therefore redirected into other channels in an effort to explain the patient's symptoms. Two of the 7 patients in this group in which the absence of a block had been demonstrated were re-examined later by completely draining the cerebrospinal canal and replacing with air. Roentgenograms of the cervical spine were taken in the upright position and intramedullary lesions, which were not blocking the cervical canal, were clearly demonstrated with the negative contrast. Both these patients were operated upon and the lesions proved to be as visualized in the film studies. It was felt, therefore, that a more adequate means of visualizing the cervical spinal canal was needed. The following procedure and method of examination was therefore devised.

Studies Made by Manipulating 40–50 cc. of Air into the Cervical Spinal Canal. This method of examination makes use of the fact that a volume of air in a column of fluid will always seek the highest level of the column. Therefore, 40–50 cc. of air placed in the lumbocaudal canal will, as the patient is maneuvered into various positions, behave in much the same manner as the bubble of air in a carpenter's spirit level. By taking advantage of this fact, the air can be moved into any section of the spinal canal selected for study.

The lumbar puncture and injection of air may be done at the bedside or in the roentgen-ray department if preferred, and consumes little more time than the routine lumbar puncture. The patient is placed on a stretcher in the lateral recumbent position with a pillow under the flank, as demonstrated in Figure 1*A*. The lumbar puncture is made in the routine manner in the third or fourth interspace and the Queckenstedt test is done. Spinal fluid is then replaced with air in 5 cc. increments until a total of 40–50 cc. of air has been admitted to the subarachnoid space. With the patient in this position, the column of air is now confined to the lower thoracic and upper lumbar area. This position is maintained during transportation to the roentgen-ray department, if necessary, or until the roentgenograms are to be taken. At this time the patient is gently turned onto his back with the pillow kept in place or moved slightly toward the patient's feet. At the completion of this maneuver the patient is lying supine with the pillow beneath the lower lumbar region; in this position, the air is in the lumbocaudal sac. A 4 to 6 inch block is then placed beneath the shoulders and the neck extended, thus forming a trap in the lower cervical area. This curve or trap is used to control the upward movement of air during the following maneuvers. The pillow is then removed from beneath the lumbar spine and the patient is in the position as demonstrated in Figure 1*B*. The highest point of the column in this position is at the upper thoracic level. The patient is then questioned about any undue discomfort in the back. Contrary to Dandy's original thought, that the presence of air in the spinal canal produces no symptoms except at the level of a lesion, as the air seeks its upper level in the canal, the pa-

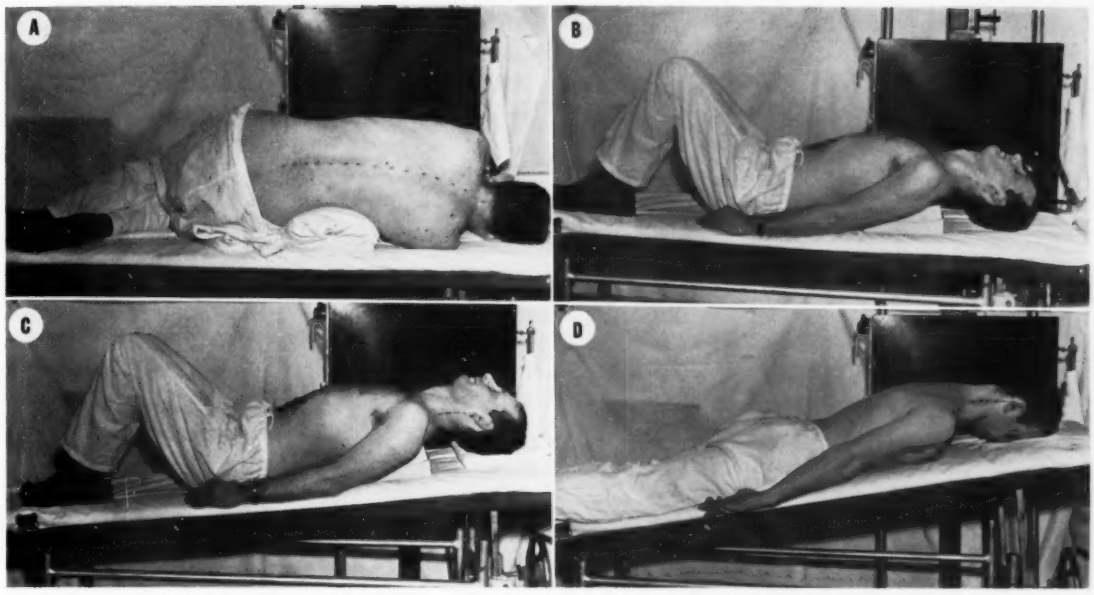

Fig. 1. Positioning of patient for cervical air myelography with 40–50 cc. of air. (*A*) Position for injection of air and transport to roentgen-ray department. The air is situated in the lumbar and lower thoracic canal. (*B*) In this position the air is trapped in the upper thoracic canal and prevented from surging into the head by the extreme extension of the neck. (*C*) Final attitude of patient for visualization of anterior subarachnoid space in cervical canal (see Fig. 3). (*D*) Positioning of patient for visualization of posterior subarachnoid space (see Fig. 4).

tient will experience localized sensation, ranging from mild pressure to moderate pain.

The head end of the stretcher is now very slowly elevated and the progress of the column of air, as it rises in the spinal canal, is determined by the patient's subjective reaction. As the air reaches the level of the fourth thoracic vertebra, the patient usually complains of discomfort across the shoulders. At this point care is taken to exaggerate the extension of the neck to prevent a sudden surge of air into the head. The head is now gradually elevated and the progress of the air in the cervical canal noted by the needle-point pain the patient experiences in the midline of the neck posteriorly. As the air spills over the anterior rim of the foramen magnum and rises along the clivus to the sella, the patient will suddenly exclaim of pin-point bitemporal headache, often associated with lacrimation. In this position (Fig. 1*C*), the neck is leveled so as to distribute the air throughout the length of the cervical canal.

A lateral stereoscopic pair of 10 by 12 inch films is made on the upright Potter-Bucky diaphragm with the stereoscopic shift across the air column before the patient is moved. If satisfactory visualization is not obtained, proper readjustment is made and the films retaken.

In order to complete the study, the posterior portion of the cervical canal must be visualized. From the last position described for taking films of the anterior subarachnoid space, the head of the stretcher is lowered; the pillow is replaced beneath the hip, and the block removed from the shoulders. This maneuver returns the bubble of air to the lumbocaudal sac and it is safe in this position to turn the patient over into the prone position. The head is now flexed so that the forehead and nose are touching the surface of the stretcher. The head of the stretcher is now again gradually elevated and the progress of the air up the spinal canal detected by the patient's subjective reaction. As the air traverses the cervical canal, the patient

will again complain of the needle-point pain along the midline of the back of the neck and, as the air spills into the cisterna magna, he may occasionally complain of mild occipital headache. At this point the cervical spine will be level, as demonstrated in Figure 1*D*. Similar films are taken in this position for visualization of the posterior subarachnoid space and cisterna magna (Fig. 4).

Fifty-nine studies were made in this manner. In 47 of the 59 studies satisfactory visualization of the cervical canal was obtained. Twelve of the studies were unsatisfactory for diagnostic purposes for the following reasons:

1. Four cases were unsatisfactory because through faulty manipulation all of the air entered the head. Two of these studies were later repeated by doing a combined encephalocervical myelogram and satisfactory visualization of the cervical canal was obtained. The other 2 studies were not repeated.

2. In 3 studies the cervical canal was visualized only as high as C_3 through faulty manipulation of the head. These studies were adequate to rule out the presence of a lesion up to that level but could not exclude the presence of a lesion in the remainder of the canal. None of these studies were repeated inasmuch as the patients exhibited no symptoms referable to that area.

3. One study was inadequate because of poor filling of the cervical canal, and films of poor contrast and density.

4. One study inadequately outlined the foramen magnum level because of poor filling in this area. A lesion was suspected clinically in this area and the study was repeated with a combined encephalocervical myelogram. The questionable area was satisfactorily visualized and found to be negative.

5. In 1 case the air could not be manipulated past T_4 and no air was visualized in the spinal canal. On the basis of the premise that a lesion was present at this point blocking the canal, the spinal canal at T_4 was explored and no lesion was found. A postoperative air myelogram on the same patient again exhibited the same behavior. It is interesting to note that on both occasions (before and after the exploration at T_4) the air myelography was followed by pantopaque myelography. None of these procedures visualized the lesion. The patient was operated upon on the strength of clinical findings alone and an extradural neurofibroma was removed from the cervical canal at the level of the sixth cervical vertebra.

6. In the final instance air myelographic studies were inadequate inasmuch as no attempt was made to visualize the posterior subarachnoid space. Visualization of the anterior subarachnoid space led to the supposition that an intramedullary lesion existed between C_2 and C_5. At operation, however, an intramedullary lesion was found in the medullospinal junction. Failure to visualize the posterior subarachnoid space in this case led to an erroneous diagnosis.

Studies Made after Completely Draining the Cerebrospinal Canal. Often the clinical manifestations of the degenerative and post-traumatic lesions of the central nervous system may be atypical and the problem of differential diagnosis from a tumor may arise. Encephalomyelography, therefore, can equip the examiner with a com plete objective survey of the cerebrospinal axis and may include the dorsal and lumbar canals, as well as the cervical. This method, in our experience, has been found to be the most efficient method of visualizing the cervical canal, the cord and its relationship with the brain. Its use is recommended if there has been a failure to satisfactorily visualize the canal by either of the two previously described methods or if a combined study is desired.

Injections are made in the same manner as for encephalography, with the patient in the sitting position and the neck slightly flexed. Air is exchanged for fluid in 10 cc. increments and every effort must be made to obtain a complete drainage. The patient

is kept in the sitting position and placed before the Potter-Bucky diaphragm. Before routine encephalographic films are taken, stereoscopic views of the cervical spine are taken in the lateral and both oblique positions at 45 degree angles. These films are developed and studied immediately. If additional films in the supine and prone positions are needed to better delineate the anterior or posterior subarachnoid spaces, they are taken as soon as possible.

An additional 59 studies were made in this manner. In 48 of the studies complete drainage was obtained and adequate visualization of the cervical spinal canal and cord was procured along with encephalographic films. In 5 of the cases the exchange of fluid for air at the time of the procedure was poor and a complete drainage could not be obtained. Films of the cervical spine in these cases demonstrated the presence of lesions partially blocking the canal. All 5 were operated upon and the lesions proved correct as demonstrated. Six of the studies were unsatisfactory for diagnostic purposes because of inadequate drainage of the spinal canal for the following reasons:

1. In 2 cases the patients were uncooperative and were straining at the time the procedure was attempted. The exchange of air for fluid was very poor and only a small quantity of air could be admitted to the lumbar canal. Films of the cervical spine were taken and in both instances air was visualized in the cervical canal up to the level of the foramen magnum, where soft tissue shadows were visualized which appeared to be blocking the canal. Small quantities of air entered the head in each case. Both studies were repeated under more ideal conditions and under anesthesia. In both instances a complete drainage of the cerebrospinal canal was easily obtained and roentgenograms failed to disclose the presence of a lesion in the upper cervical canal. Good visualization was obtained of the cervical canal, the ventricular system and subarachnoid spaces. It can only be postulated that perhaps, due to the straining at the time of the procedure, some herniation of the cerebellar tonsils occurred, which temporarily blocked the cervical canal.

2. In the 4 remaining studies the cervical canal was not visualized because the procedure had been terminated before complete drainage had been obtained. In 2 of these cases the remaining spinal fluid was drained and replaced with air immediately upon discovering the error in technique. In both instances good visualization of the cervical canal was obtained. In the other 2 cases no further studies were done.

INTERPRETATION OF THE FILMS

Preliminary routine roentgenograms of the cervical spine are taken in all cases and only after judicious appraisal of these films is the myelographic study considered.

As Dandy observed, the anteroposterior projection is of little value because of the large superimposed tracheal air shadow. This view was taken in nearly 50 per cent of the cases in this series and in not one instance could the air shadow in the canal be detected with any degree of confidence to localize a lesion.

In our experience, the lateral projection has been the most valuable. Technically this view produces a clear picture of the cervical canal and cord with a minimum of superimposed bone shadow and anatomically yields the most information. This is especially true in the presence of lesions encroaching upon the canal from the anterior direction. These lesions are usually herniated discs and they carry the posterior longitudinal ligament dorsad so that encroachment upon the ventral air column is apt to be well visualized. Where such disc herniations are accompanied by characteristically projecting osteophytes, the myelographic procedure may add very little to our understanding of the lesion.

The most complete picture of the cervical canal and cord can be obtained in the lateral projection following total drainage of the cerebrospinal space and replacement with air (Fig. 2).

The roentgenograms are exposed with

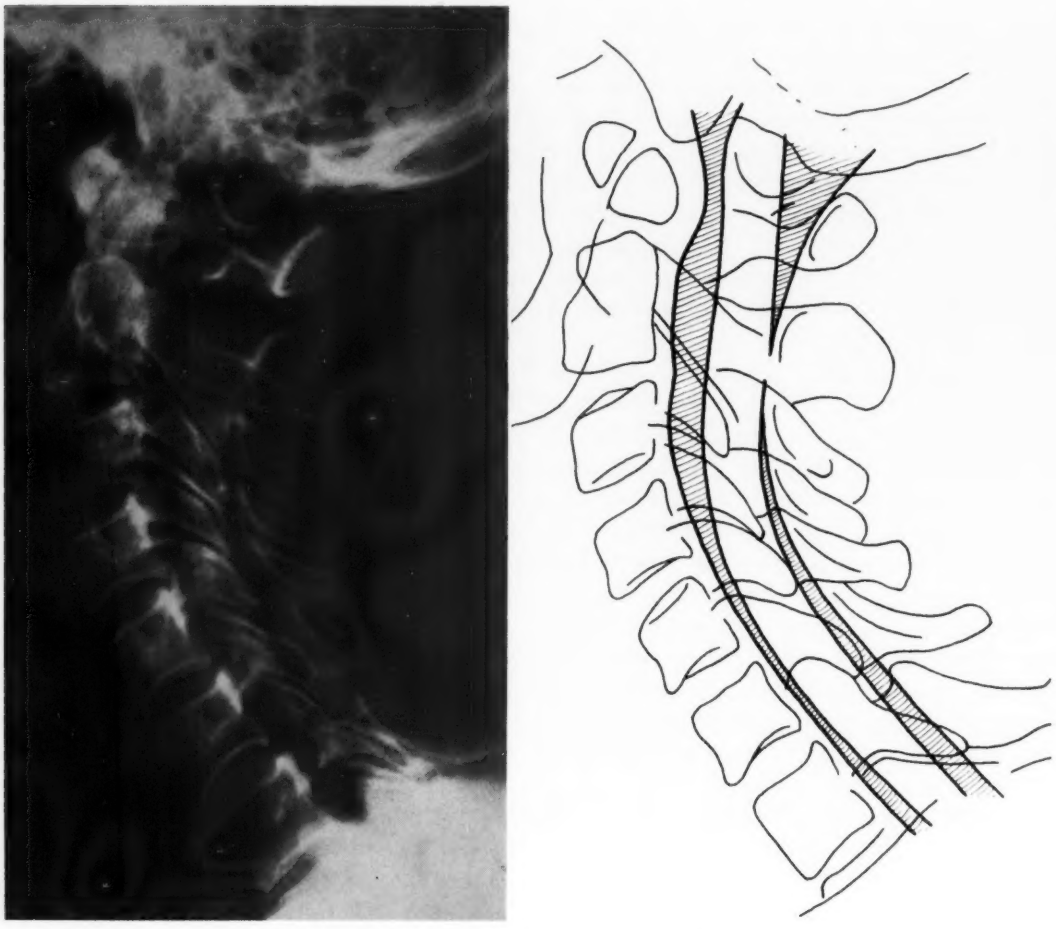

FIG. 2. Lateral view of cervical canal following complete drainage of cerebrospinal space and replacement with air. Films taken with patient in the upright position.

the patient upright, and, by taking care to depress the shoulders, the entire canal as low as the seventh cervical vertebra can be seen in most cases. By virtue of the negative contrast the cord itself can usually be visualized in its entire length, as it follows the curve of the cervical canal. Care must be taken, however, in positioning the patient for films to insure slight forward flexion of the head and neck to promote filling and visualization of the dorsal subarachnoid space, particularly in the lower levels of the canal. In this area, at least below C_3, the cord occupies the middle of the canal; and if the neck is held directly vertical or in slight extension, the dorsal subarachnoid space may not fill. The cord is most dorsally placed at a point behind the second cervical vertebra and here it may lie in the dorsal surface of the canal. At the level of the second cervical vertebra the canal begins to widen in a funnel-like manner and the dorsal air shadow can be seen beginning again at this point and sweeping back in a gentle even curve through the dorsal rim of the atlas to the posterior rim of the foramen magnum where it becomes continuous with the cisterna magna. The cord can be seen rising vertically in this space and penetrating the foramen magnum usually in the anterior one-half of the foramen. This situation is ideal for the visualization of non-blocking lesions in this area, into which it is difficult

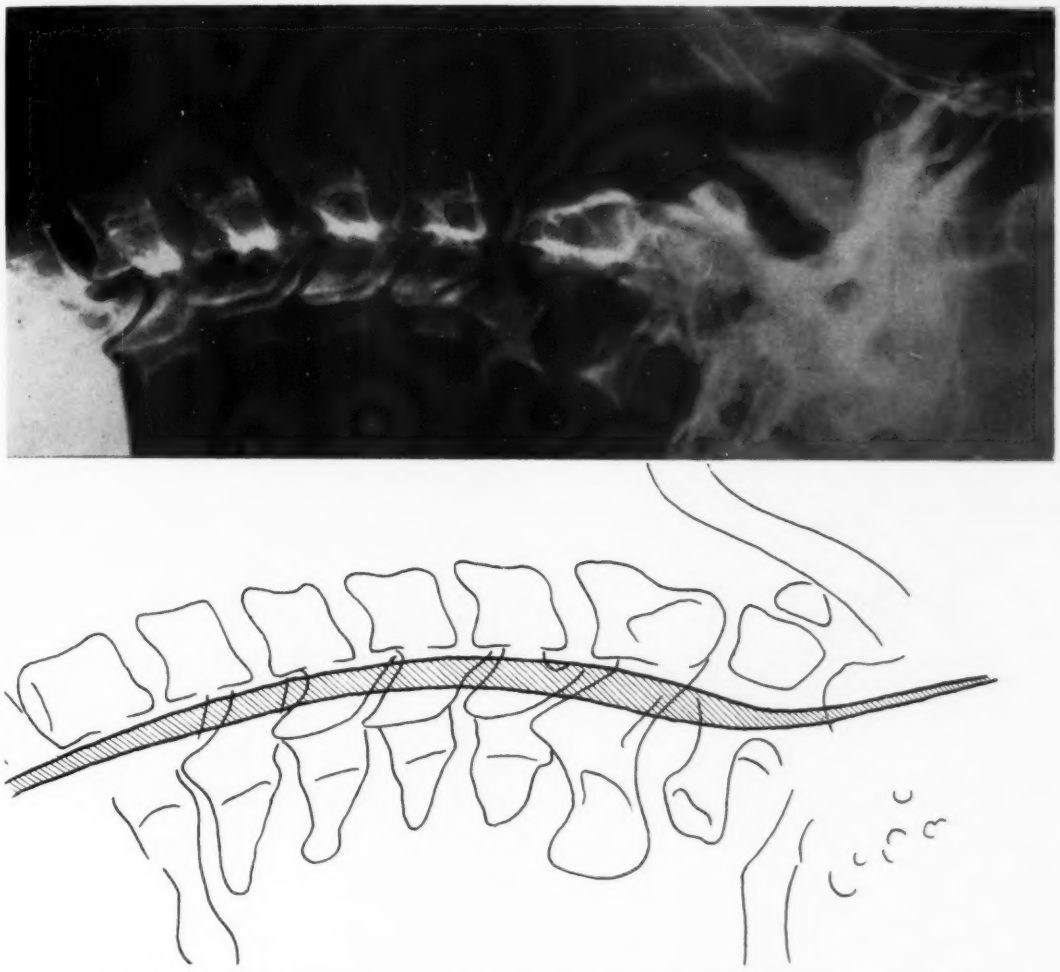

Fig. 3. Negative cervical air myelogram with 50 cc. of air demonstrating anterior subarachnoid space.

to manipulate a viscid, positive contrast agent such as pantopaque.

While the anterior subarachnoid space is well visualized in the upright position, it is most graphically demonstrated in the supine position with the horizontal ray. Thus, the air in its effort to seek the highest level balloons out the arachnoid and presses it against the anterior limiting membrane, affording an excellent opportunity to visualize lesions encroaching from this direction (Fig. 3).

In those cases considered to be normal, the ventral air column occupied one-third or less of the width of the bony canal below C2 and was narrowest behind C5 and C6. Behind C4 and C3 and the lower half of C2 the column was uniform in width but behind the upper portion of C2 there is initial slight widening as the bony canal itself begins to expand. Behind the odontoid, however, the air column again becomes narrowed as the cord curves ventrad and approaches the soft tissues behind the odontoid. The column then follows the forward angulation of the cord as it joins the medulla and can be seen following the clivus to the dorsum sellae.

The dorsal surface of the cord, the dorsal subarachnoid space and its relationship with the cisterna magna can best be demonstrated by placing the patient in the prone position and taking films with the horizontal ray (Fig. 4).

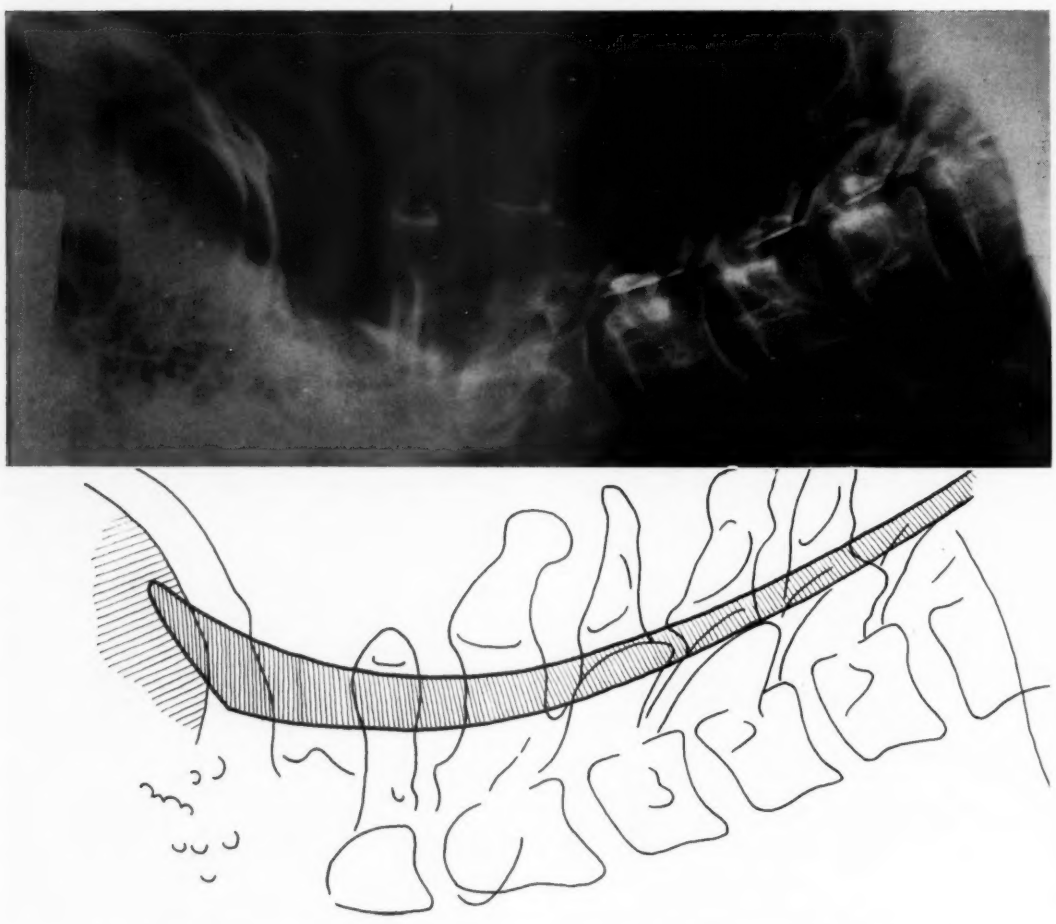

FIG. 4. Negative cervical air myelogram with 50 cc. of air demonstrating the posterior subarachnoid space and relationship with cisterna magna.

In cases with so-called "complete drainage" of the canal we have routinely made right and left oblique views with the patient upright, at 45 degree angles. In these projections the cord can readily be seen and some evaluation of its width obtained. They have been particularly valuable in visualization of the critical cervicodorsal junction in some cases (Fig. 5).

Accurate diagnosis with air myelography requires careful, painstaking study of stereoscopic films of the best quality and contrast, with close correlation of the clinical findings. If definite evidence of an encroaching or expanding lesion exists, and accurate localization cannot be made with air, the use of a positive contrast agent may be indicated. In our own experience this has happened quite infrequently. In this present series positive contrast myelography was used where air myelography gave controversial findings in only 5 studies.

In no instance did the pantopaque myelogram add to our understanding of the case. In 1 of these 5 studies pantopaque falsely located a lesion, as did the air. In another study the pantopaque myelography was of no value for diagnosis. In 2 cases with midline cervical disc protrusion, pantopaque myelography did not demonstrate the marked cord atrophy which was present. The midline disc was demonstrated both by air and pantopaque in 1 of these 2, and in the second the pantopaque did not visualize the disc protrusion but the air did. The fifth was a case of

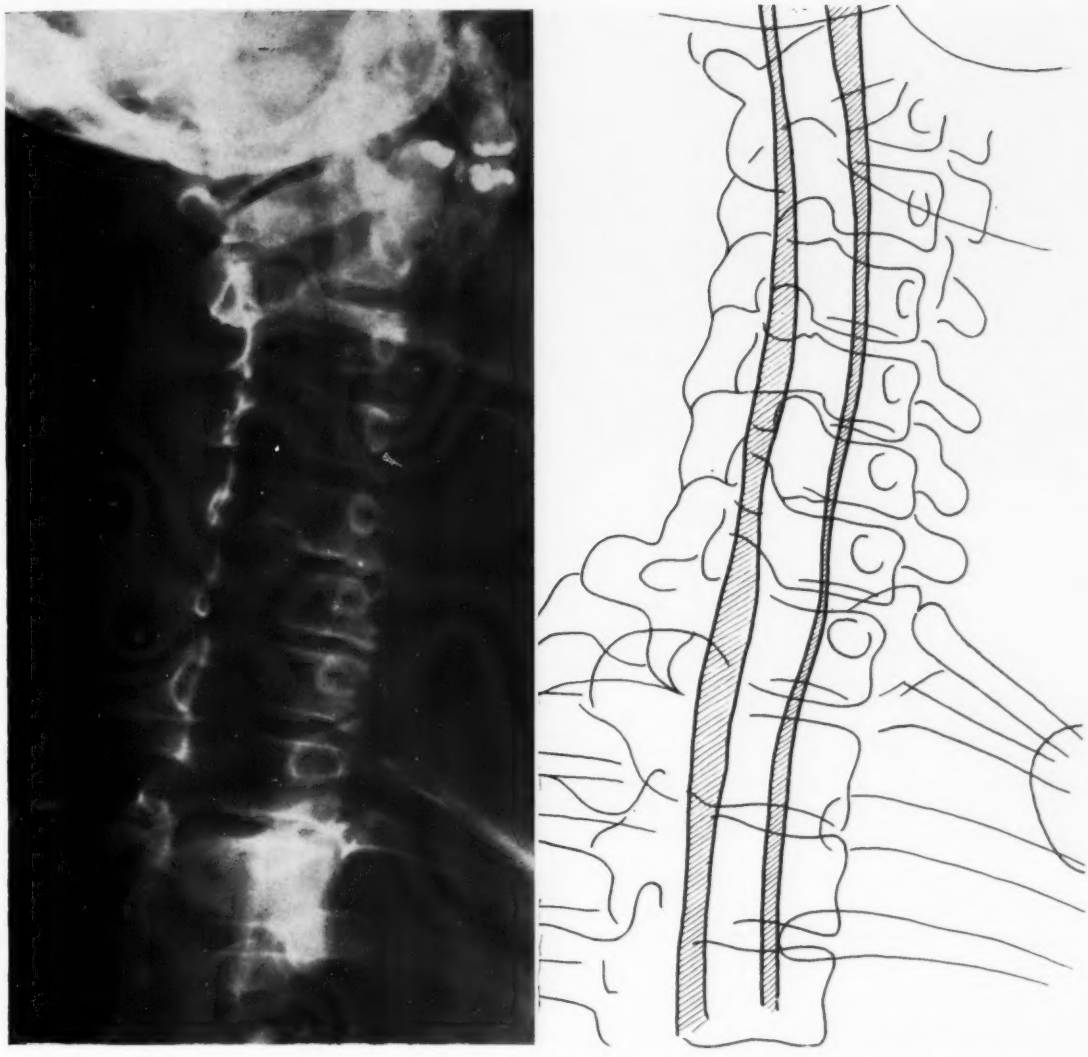

Fig. 5. Oblique view of cervical canal in the upright position following complete drainage. Note the visualization of the cervicodorsal junction.

bony anomaly at the craniovertebral junction. Air myelography demonstrated the bony encroachment and the extensive cord atrophy present. The pantopaque myelogram did not visualize the cord atrophy and, because of the difficulty in manipulating the oil at the craniovertebral junction, encroachment at this point was not demonstrated.

MALFORMATIONS OF THE CERVICAL SPINE WITH CORD COMPRESSION

In this group there were 10 cases with bony anomalies of high cervical spine and base of skull. All 10 cases exhibited symptoms of cord deficit and in 4 cases the clinical impression was that of multiple sclerosis or syringomyelia. Encroachment on the cord at the level of the bony anomaly was clearly demonstrated by air in 8 cases.

In 1 of the other 2 cases 10 cc. of air introduced into the lumbar canal ascended immediately into the head, demonstrating the absence of a block in the canal. This patient was not operated upon. In the other, myelographic studies were done postoperatively only and conclusively dem-

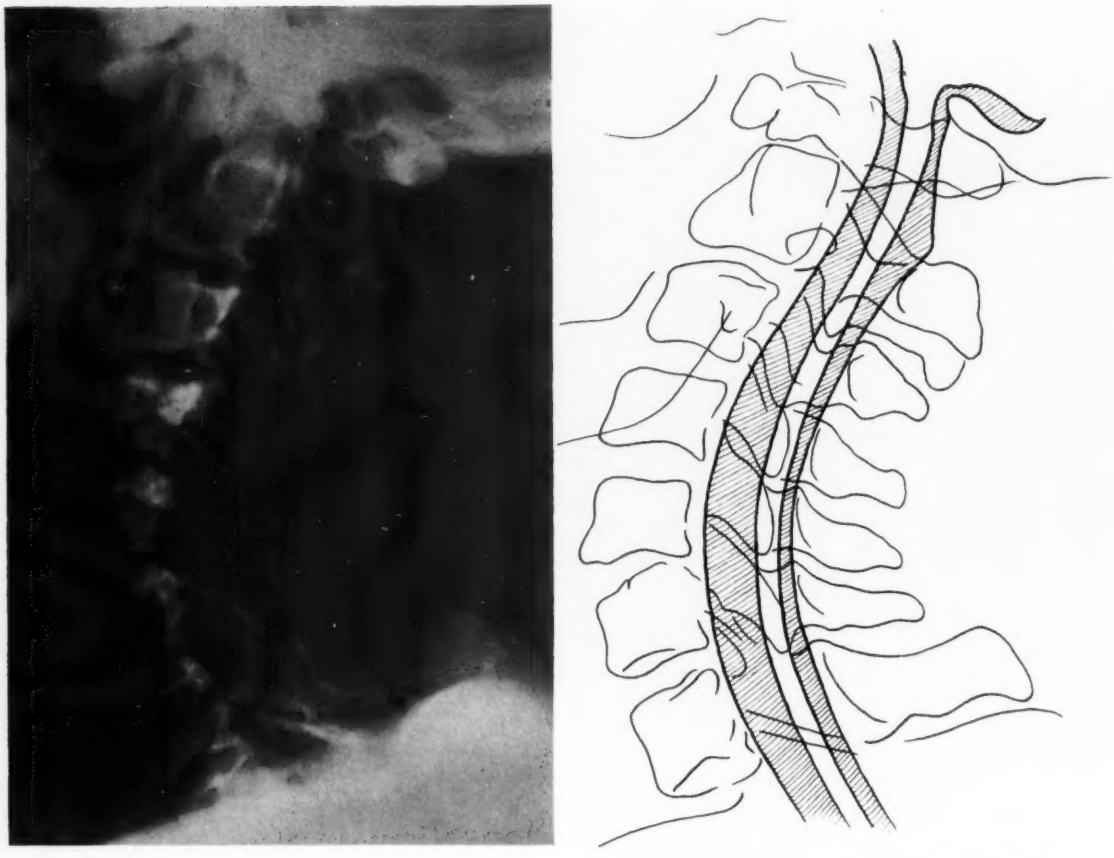

FIG. 6. Cervical air myelogram in a patient originally diagnosed as having syringomyelia and in whom "platybasia" had been demonstrated in the plain films. Note the encroachment upon the medullospinal junction by the bony rim of the foramen magnum posteriorly and the marked atrophy of the cord which was proved surgically.

onstrated adequate decompression of the canal.

In 4 of the 8 cases myelography visualized blocking of the canal at the foramen magnum level. Operation in 3 of these cases uncovered the bony anomaly, and in addition the presence of a dense fibrous extradural band of tissue at the medullospinal junction. The fourth case was not operated upon because of her age and rapid clinical improvement following a fall which had precipitated the symptoms.

In 2 cases soft tissue masses were visualized in the posterior canal partially blocking the spinal canal as low as the third cervical vertebra; these were felt to be herniated cerebellar tonsils. High cervical laminectomy in both cases uncovered Arnold-Chiari-like deformities with herniation of the tonsils to the level demonstrated.

Two cases graphically demonstrated the unique value of negative (air) contrast, due to its ability to visualize the cord. In both cases bony encroachment at the medullospinal junction could be clearly seen, and in addition marked atrophy of the cord was strikingly visualized (Fig. 6). At operation the cords were found to be flat, ribbon-like structures, with markedly increased vascularity and with hour-glass constrictions at the medullospinal junction. In our experience the opaque contrast media have not been suitable for visualization of the cord. For example, in 1 of these cases of marked cord atrophy, we had evidence that a block was not present and pantopaque myelography was carried out, subsequent

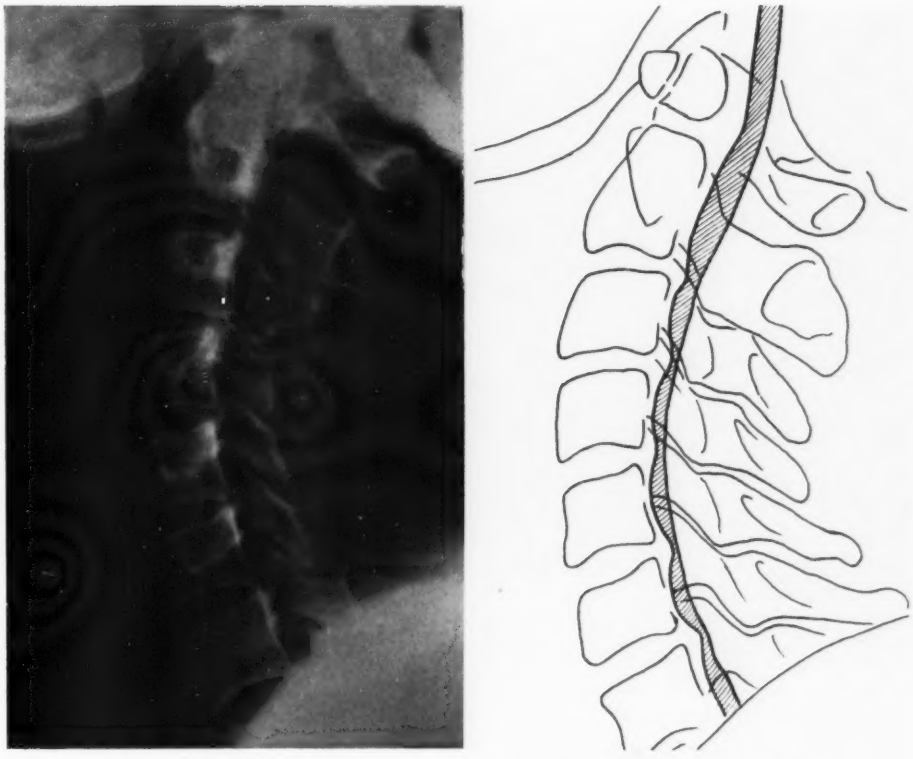

Fig. 7. Myelogram with 40 cc. of air demonstrating multiple soft tissue encroachments upon the ventral air column.

to the air studies, but before the operation. Except for some difficulty in maneuvering the oil into the cisterna magna, no abnormality of the canal or cord could be demonstrated.

AIR MYELOGRAPHY IN CERVICAL SPINE INJURIES

In the presence of trauma to the cervical spine with or without demonstrable fracture or dislocation and with positive neurological signs, the question frequently arises whether decompression should or should not be done. The demonstration of the presence or absence of a block in the canal may be the deciding factor. Queckenstedt testing may give equivocal results and in such cases the use of a small quantity of air is extremely valuable.

In the presence of a complete block, as little as 5 cc. of air will clearly demonstrate the level; therefore, the procedure can be accomplished with a minimum of manipulation of the patient. The patient need not be raised to the sitting position following the injection of the air. The body axis can be changed by elevating the stretcher or table until the head is high enough so that any air in the spinal canal would ordinarily run into the cranial cavity. The clinical reaction of the patient, particularly as to whether or not he develops headache, will usually suffice to indicate to the operator the presence or absence of a block. Roentgenograms may then be made at the indicated level and objective evidence of the block obtained if one is present.

There were 4 such cases in this series. Two cases were completely blocked. The level of block was clearly demonstrated on the myelograms and, at the time of decompressive laminectomy, the block was found to be present at the level demonstrated. Two cases adequately exhibited the absence of a block and were not operated upon.

Frequently patients with definite histories of trauma to the head and neck ex-

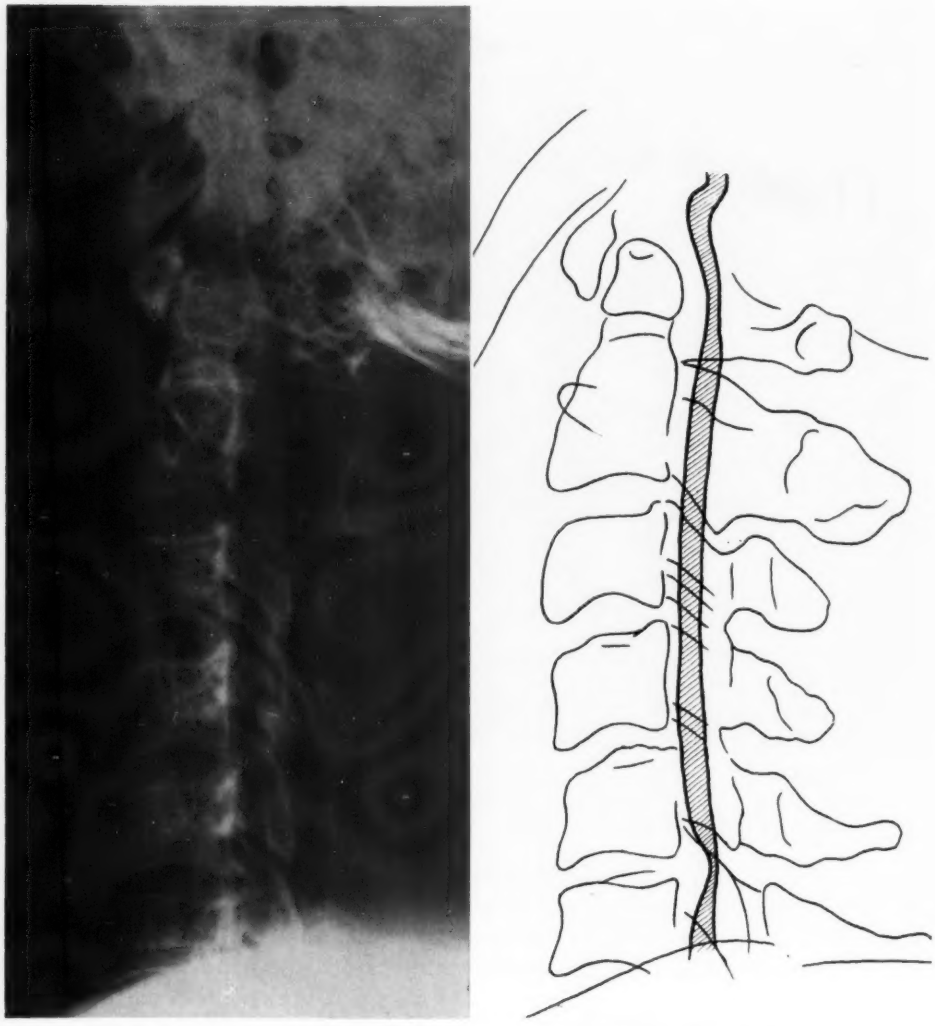

Fig. 8. Myelogram with 40 cc. of air demonstrating protrusion of cervical disc between C5 and C6, proved by surgery. Plain films did not suggest disc disease in this patient.

hibit persistent subjective or objective neurologic findings referable to the cervical spine and cord. These patients fall into the category of the so-called post-traumatic syndrome and the differential diagnosis from tumor or other encroaching lesions in both the brain and cervical spinal cord arises. Combined encephalomyelography, which can include the thoracic and lumbar canal, provides the clinician with a complete objective survey of the craniovertebral axis.

Twenty-two such studies were made in this series. Satisfactory visualization of the cervical canal and cord was obtained in 19 studies. Three studies were unsatisfactory for diagnostic purposes.

Intervertebral Disc Herniations and Osteophytosis

Herniation of an intervertebral disc or encroachment on the cervical roots and cord by protruding osteophytes was suspected in 25 cases and was found to be the cause of the neurologic syptoms in an additional 10 patients suspected of having tumors. Air myelography gave adequate visualization in 32 cases. Three cases were unsatisfactory for diagnosis.

These 35 cases fall into four distinct

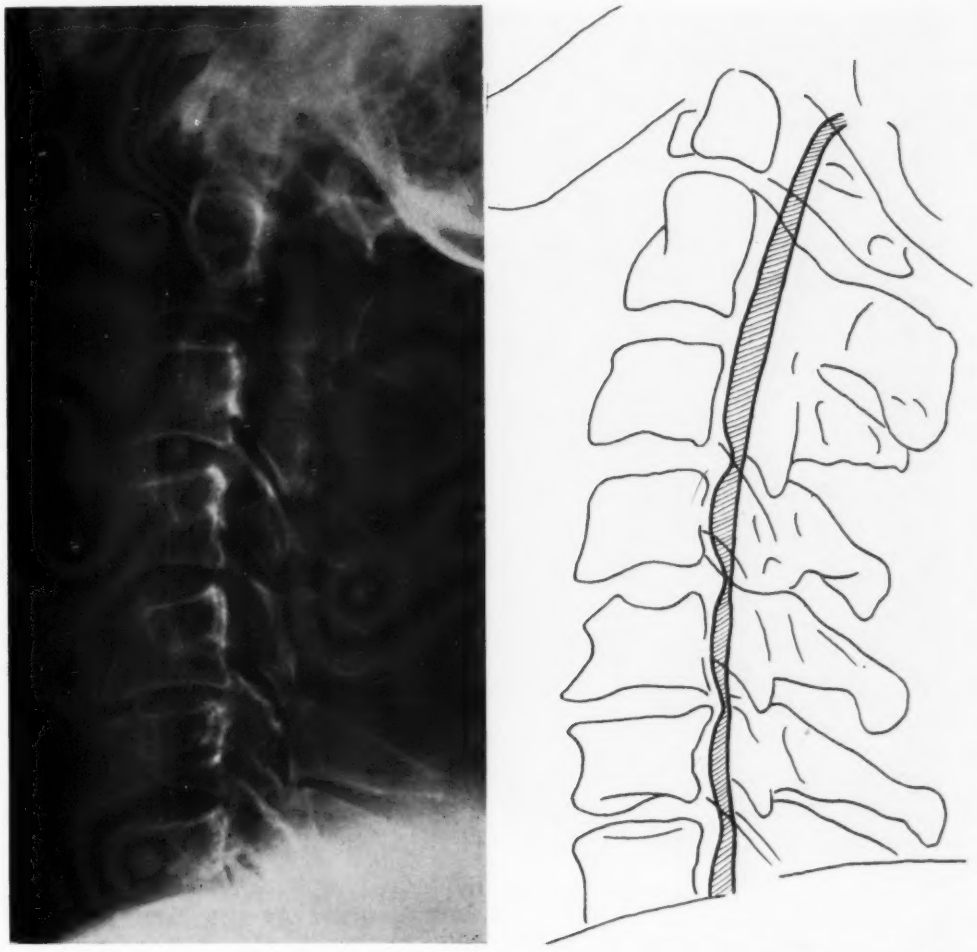

Fig. 9. Myelogram with 50 cc. of air demonstrating encroachment upon the ventral air column between C_5 and C_6 as suggested on the plain films, but also demonstrating encroachments at the unsuspected interspaces between C_3 and C_4, C_4 and C_5, C_6 and C_7.

clinical groups:

1. The first group includes 10 patients who exhibited vague neck, shoulder and arm pain with some intermittent paresthesias in the fingers but with no positive, objective neurologic signs which would suggest involvement of a single root. In 3 of these the plain films gave no hint of degenerative disc disease. In 1 of these 3 cases, however, a subsequent air study visualized moderate soft tissue encroachments on the ventral air column at several levels (Fig. 7). In each of the remaining 7 cases the plain films suggested disc herniation or significant encroachment by protruding osteophytes. The plain films showed loss of stature of one or more disc spaces, constriction of vertebral foramina, or protruding osteophytes at dorsal corners of one or more vertebral bodies, findings which suggested possible disc herniation or significant encroachment by such osteophytes. Air myelography demonstrated significant encroachment in only 2 of these 7 cases. All of the cases in this group were treated conservatively or were found to have disease elsewhere than in the spinal canal. None was operated upon.

2. The second group includes 13 cases which exhibited typical cervical root pain. In 6 of these the objective neurologic findings clearly indicated the involved root, and in 7 cases, involvement of one or two or more roots on the same side could be sus-

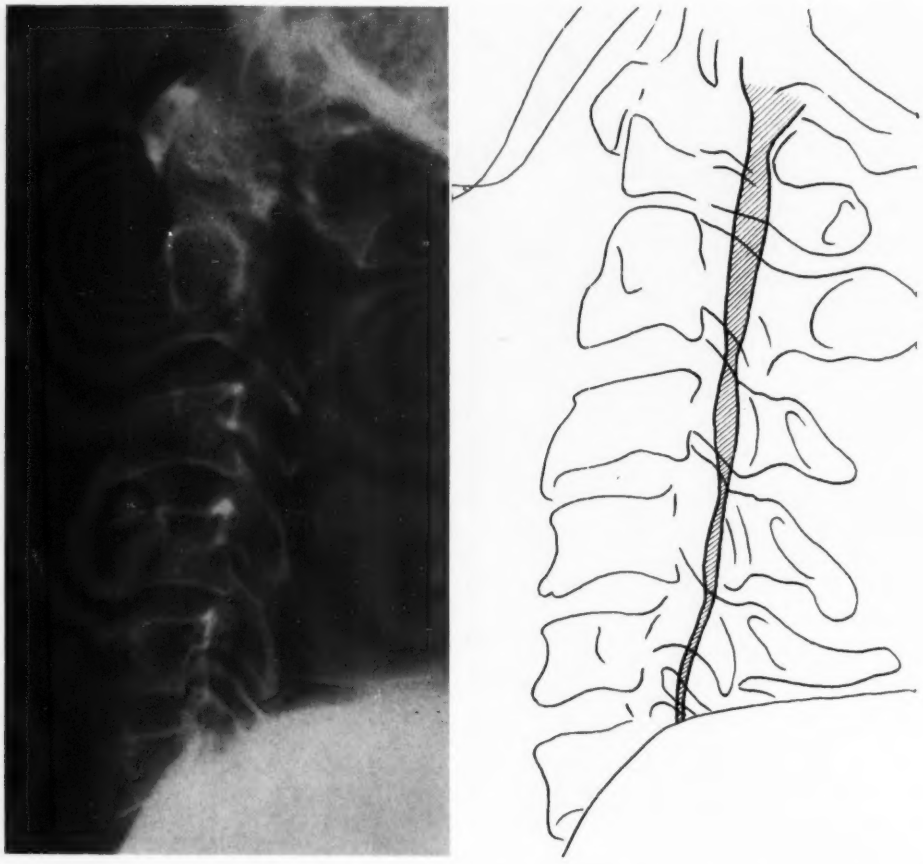

Fig. 10. Myelogram with 50 cc. of air demonstrating marked encroachment upon the ventral air column by piled up osteophyte formation as a result of advanced degenerative bone, joint and disc disease. Clinical picture suggested amyotrophic lateral sclerosis.

pected. One case in which the clinical findings clearly indicated involvement of the sixth cervical root, gave no suspicion of disc herniation on the plain film but myelography demonstrated major encroachment on the ventral air column by a soft tissue mass behind the fifth interspace (Fig. 8). Laminectomy in this case uncovered a large soft mass of disc material compressing the roots at the level demonstrated. In 11 of the 13 cases myelographic demonstration of encroachment closely corresponded with the bone changes in the plain film and with the clinical findings, but in 1 case suspected of having encroachment by osteophyte formation at the fifth interspace, unsuspected multiple soft tissue protrusions were visualized at several additional interspaces (Fig. 9). Five of the 13 patients were operated upon; soft fibrocartilaginous material was removed over the osteophyte protrusion. All lesions were found to be situated as demonstrated by the air myelogram.

3. The third group includes 5 cases which, in addition to having definite root-type pain, presented motor weakness of the extremities, and in 3 cases definite evidence of cord deficit. The plain films in all of these cases exhibited degenerative bone, joint and disc disease. Myelographic studies demonstrated marked encroachment upon the ventral air column by osteophyte formation and in 1 case there was a complete block. The 3 cases exhibiting cord signs were operated upon and local cord compression by the osteophyte formation was found in all cases as demonstrated myelographically.

4. The fourth group includes 7 cases in

which there was no complaint of root pain. There was, however, in all 7 a history of root type pain in the past. All exhibited positive neurologic findings suggestive of cord deficit in the cervical area and most were suspected of having tumors in the cervical spinal canal. Three of these cases presented the clinical picture of spastic quadraparesis. The plain films suggested degenerative disc disease at a single level. The myelographic picture was that of encroachment on the ventral portion of the cord by a single posterior protruding osteophyte and the cord appeared thinner than usual by negative contrast. These 3 patients were all operated upon and at operation midline protrusions of osseous material were found encroaching on the anterior aspects of the pale atrophic cord in all cases.

Of the 7 cases in this group without present pain but with a past history of such, the remaining 4 cases presented clinical pictures simulating amyotrophic lateral sclerosis with marked weakness of the upper extremities, atrophy of the interosseous muscles and muscles of the forearms, the arms and the shoulder girdles; pyramidal tract signs were present in all 4 cases. The plain films in these cases demonstrated advanced bone, joint and disc degeneration at several levels in the cervical canal with piling up of osseous material on the dorsal surfaces of the vertebral bodies. Myelography demonstrated marked encroachment upon the anterior portion of the cord by the massive osteophyte formation which almost occluded the ventral air column and spanned several segments (Fig. 10). Three of these patients were operated upon and decompressed. At operation pale, flat cords were found stretched over the bony protruding masses.

SPACE-TAKING LESIONS OF THE CERVICAL CANAL

(Tumors, suspected tumors, syringomyelia and intramedullary hemorrhage)

This group presents the greatest difficulty in visualization by air and, when visualized, offers the greatest challenge in interpretation.

Of the 18 cases in this group, lesions were successfully visualized and proved by surgery in 13. In 2 cases myelography merely demonstrated the absence of a block in the cervical canal but were of no value for diagnosis inasmuch as the canal was not visualized; in 2 cases the air myelography was definitely misleading and failed to demonstrate the major lesions which were found at higher levels in the canal; 1 patient in which a lesion had been visualized was not operated upon.

In 12 of these 18 cases the Queckenstedt test was either positive or equivocal and it is interesting to note that in not one case did the myelogram demonstrate an actual complete block of the canal. Even in those cases in which massive lesions were later found, which appeared to completely fill the canal, some air could be made to pass the block by manipulating the head in various directions.

Five of these cases were studied with small quantities of air with the patient in the upright position; partial blocks were demonstrated in 4 cases and these were found to be at the level of the lesion, as proved later by surgery.

The remaining 13 cases were studied either by manipulating 40–50 cc. of air into the cervical canal or by completely draining the cerebrospinal canal and replacing with air. In 12 cases a lesion was successfully visualized and proved in 10. In 1 case the myelogram demonstrated a false level and the patient was found to have a lesion several segments higher. In the remaining case, swelling of the cord was visualized but the major intramedullary lesion, at a much higher level, was not seen.

It was possible in 7 of these cases to diagnose the lesions as either intramedullary or extramedullary from the air myelogram. The intramedullary lesions can be easily recognized as fusiform enlargement of the cord with gradual pinching off of the air column as the mass fills the canal (Fig. 11). The extramedullary lesions, on the

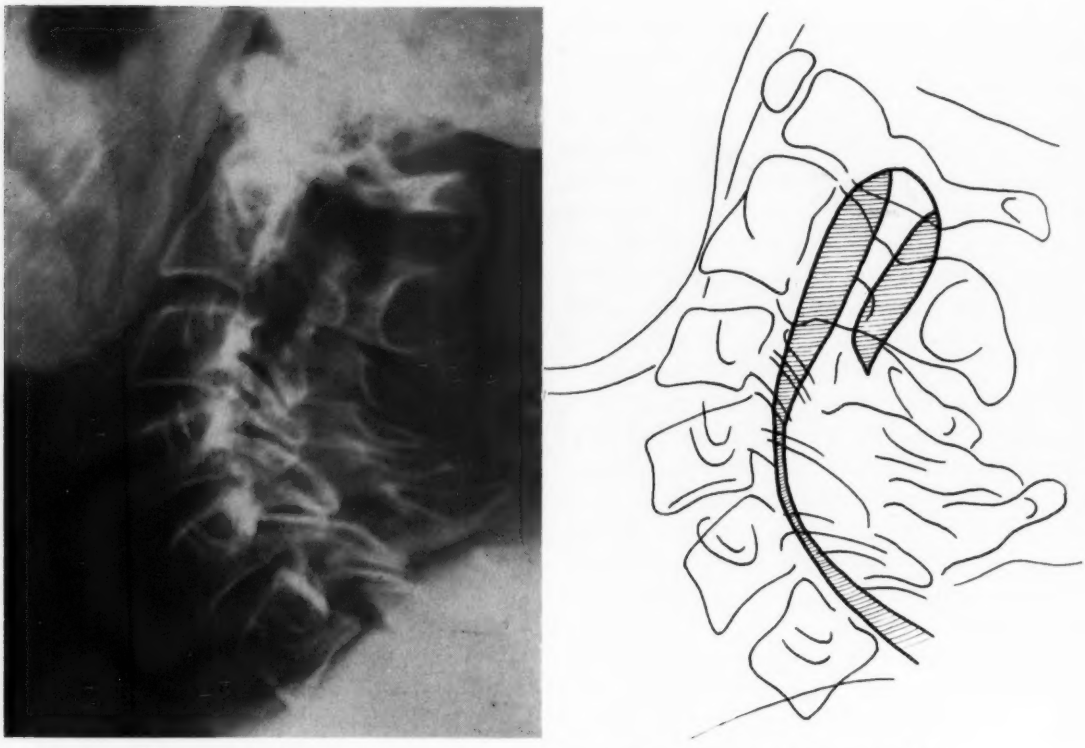

FIG. 11. Myelogram demonstrating an intramedullary lesion in the cord which, at operation, proved to be syringomyelia.

other hand, sharply constrict the air column and displace the cord.

The value of the use of the larger quantities of air is clearly demonstrated by 1 case in this group. The patient was suspected of having an intramedullary lesion in the cervical cord. On the first study a small quantity of air was introduced into the lumbar canal and the patient was placed in the upright position. All of the air immediately ascended into the head, thus clearly demonstrating the absence of a lesion blocking the cervical canal but providing no other diagnostic information inasmuch as the cervical canal and cord were not visualized. The patient's clinical picture strongly suggested the presence of a lesion in this area, however; a complete drainage of the cerebrospinal canal with adequate visualization of the cervical area demonstrated the presence of a fusiform enlargement of the cord which was not producing a block. This patient was operated upon, and an intramedullary hemorrhage was found.

DEGENERATIVE LESIONS OF THE CENTRAL NERVOUS SYSTEM

An outstanding feature of negative contrast myelography in the cervical region is the visualization of the cord. Demonstration of the fusiform enlargement of the cord produced by intramedullary lesions has already been discussed.

The myelographic diagnosis of cord atrophy may at times be difficult to establish. In view of the individual diversity of cord size and size of the canal, in conjunction with the variability of magnification in the roentgenogram, any fixed figure for normal cord thickness would be unreliable. It can be said, however, that in those cases in our series in which no cervical cord or canal disease could be found, and in which no clinical evidence of cord deficit existed, the thickness of the cord measured from 8 to 11 mm. In all cases where the diagnosis of cord atrophy was made myelographically the cord measured considerably less than 8 mm. in thickness (Fig. 12). This finding, in addition to its presence in

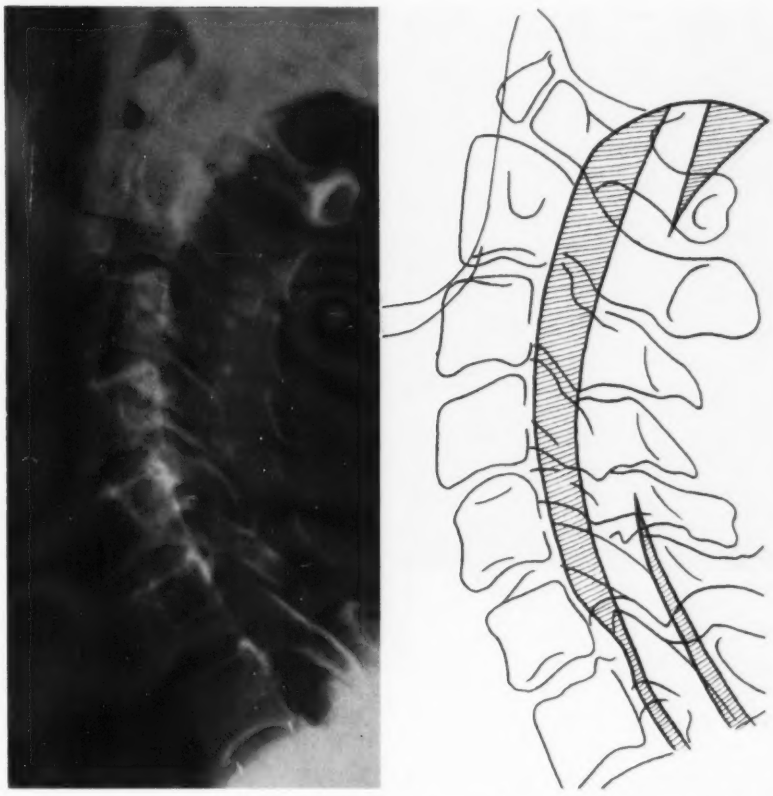

Fig. 12. Myelographic portion of a combined encephalocervical myelogram in a patient with the clinical picture of multiple sclerosis. Although the cord measured 9 mm. on the film, the visible air column occupied nearly half the width of the canal except behind the sixth interspace where there is some protrusion of the disc. The encephalographic films suggested cortical atrophy.

8 cases of multiple sclerosis and in 4 cases of amyotrophic lateral sclerosis, was present in the myelogram and proved surgically in 2 cases of "platybasia" and in 2 cases of massive encroachment of the ventral cervical cord by piled up osteophyte formation.

It has been previously noted in this series of cases in which we excluded expanding or degenerative lesions of the cord, the visible air column occupied one-third or less of the bony canal. It is our feeling that in those cases presenting clinical evidence of a degenerative central nervous system disease, in which no encroaching lesion could be demonstrated, an appreciable widening of the visible air column beyond one-third the width of the bony canal is suggestive of cord atrophy regardless of the measurable cord thickness (Fig. 13). This finding, in addition to being present in 2 cases of multiple sclerosis and 3 cases of amyotrophic lateral sclerosis, was present in 4 cases of encroachment by dorsally protruding osteophytes and was proved surgically in 2 cases in which the protrusion was in the midline.

Multiple Sclerosis. The clinical manifestations of multiple sclerosis usually follow a reasonably characteristic pattern. At times, however, the neurologic findings may be bizarre and signs of cord deficit may be predominant, leading to the suspicion of cord tumor. It is here that air is a particularly valuable agent, permitting an objective survey of the entire craniovertebral axis and its contents through encephalomyelography.

It is worthy of note that 3 patients in this entire group, in which the diagnosis of multiple sclerosis had been made clinically, proved to have isolated lesions of the

Fig. 13. Encephalomyelogram in a patient with the clinical picture of multiple sclerosis. Note the marked thinning of the cervical cord which measured 6 mm. in thickness.

medullospinal junction. Two had bony malformations of the first cervical vertebra and base of the skull which were demonstrated on the plain film. Myelographic study visualized compression of the cord at this level and both were proved surgically. In the third case the plain films were negative but air study disclosed a partial block at the foramen magnum. Operation disclosed an intramedullary tumor of the lower medulla in this case. Air study in the 1 additional patient with a diagnosis of multiple sclerosis demonstrated fusiform enlargement of the lower medulla and cord as low as C5 in an unusually wide cervical canal. Adequate room existed in the canal for the enlarged cord. This patient has not been operated upon.

Seventeen patients were believed to have multiple sclerosis. None were verified by postmortem examination but all exhibited with some slight deviation the clinical course and neurologic manifestations attributed to this disease. In 7 cases the air study was completely negative with no deviation from the normal cerebral pattern or alteration in the appearance of the cord.

In 2 cases there was widening of the visible air column throughout the length of the canal. Although the cord measured within the lower limits of normal, it was felt to be suggestive of atrophy. Evidence of cortical atrophy was present (Fig. 12).

Eight cases exhibited evidence of cervical cord atrophy and in all 8 there was associated cortical atrophy (Fig. 13).

Amyotrophic Lateral Sclerosis. In 11 cases of amyotrophic lateral sclerosis, the differential diagnosis from cervical cord tumor arose. A definite history of trauma was present in 3 cases. In 1 case 10 cc. of air immediately entered the head when the patient was placed in the upright position, thus disproving the presence of block. In 10 cases the cervical cord was visualized and appeared normal in 3 cases. In 3 cases there was suggestive thinning of the cord and in 4 cases the cord appeared to be definitely atrophic.

CONCLUSIONS

The use of air as a contrast medium in myelography provides an easy and harmless yet effective means of visualizing the cervical canal and cord. It possesses the obvious disadvantage in incapacitating the patient for the time necessary for absorption of the air. During this period the patient may also experience severe headache if air has entered the head during the procedure. The medium is innocuous, has no prolonged irritative effects and, once absorbed, leaves no trace which could possibly be thought to cause further symptoms. This fact may be of value in certain medicolegal and compensation cases.

Contrast with air is certainly not as striking as with the radiopaque agents. Interpretation of the films is difficult and the possibility of error is therefore increased. With the use of stereoscopic films of good technical quality and careful correlation with the neurologic findings and the clinical symptoms exhibited by the patient during the procedure, this possibility can be greatly reduced.

In the presence of a complete block, the injection of a small quantity of air (5 cc.) will clearly demonstrate the lower level of block.

Nonobstructive lesions can be visualized with larger quantities of air. This is of particular value in lesions at the medullospinal junction and foramen magnum area where it is difficult to manipulate the viscid, radiopaque agents in the absence of a block.

Negative contrast, by virtue of its ability to visualize the cord, is superior to positive contrast in the demonstration of cord atrophy.

The procedure is completely roentgenographic and the films obtained can be repeatedly studied by several examiners, thus eliminating the personal equation of roentgenoscopic interpretations with opaque media.

Forty to 50 cubic centimeters of air, placed in the lumbar canal, can be manipulated into any portion of the spinal canal for examination.

Complete drainage of the cerebrospinal axis and replacement with air affords the clinician a complete objective evaluation of the brain and any portion of the spinal canal.

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GALLSTONE OBTURATION

CLINICAL AND ROENTGENOGRAPHIC CONSIDERATIONS

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GALLSTONE obturation affords the alert roentgenologist the opportunity to render a correct, specific, pathologic diagnosis preoperatively. This diagnosis, made accurately, will seriously affect the survival of a patient afflicted with this condition.

Mortality statistics as high as 90 per cent have been described in this form of intestinal obstruction, although in recent years there has been a marked lowering of the mortality (currently ranging from 30–50 per cent). This reduction, in great extent, is consequent upon earlier diagnosis, and institution of early, definitive treatment.

The pathogenesis of gallstone obstruction has been excellently presented by Rigler *et al.*[32] The reader is referred to their article for a résumé of this aspect of the problem.

CLINICAL CONSIDERATIONS

The clinical manifestations of this form of obstruction are often extremely bizarre, unreliable, and misleading. It has frequently been stated that in cases with an antecedent history of gallbladder disease, possibly cholangitis, the diagnosis of gallstone ileus should be suspected if an obstruction, which relents and recurs, should develop. Our experience indicates that considerable variation in the clinical pattern exists, with the clinical features being dependent on the site of lodgment of the biliary calculus and the degree of obstruction present.

Early in the course of the disease, prior to extrusion of the calculus into the gastrointestinal tract, the signs and symptoms are usually those of an acute, possibly gangrenous, cholecystitis with pain and tenderness in the gallbladder area. As the calculus erodes through the gallbladder wall or other parts of the biliary tract, the contents of the gallbladder are discharged into the gastrointestinal tract, often with relief of symptoms (decompression of acutely inflamed gallbladder).

The most common fistulous communication occurs between the gallbladder and duodenum (Wakefield *et al.*[40] reported an incidence of 101 cases of cholecystoduodenal fistulas in a series of 152 cases of nonsurgical cholecystoenteric fistulas). Less commonly, fistulous tracts may form between the gallbladder and the colon, and on occasion may involve the stomach or jejunum. Occasionally, large calculi may enter the gastrointestinal tract through the common duct, either by means of a fistula or by erosion of the ampullary sphincter.

Dependent principally upon the size of an individual calculus (rather than number), occlusion of the lumen of the gastrointestinal tract may occur at any level from the pyloroduodenal junction to the sigmoid area of the colon.

Occasionally, smaller, faceted calculi may produce obstruction by irritation of the intestinal wall, with spasm and edema locally accounting for the obstructive phenomena. Calculi passing through the small intestine may increase in size by accretion of intestinal contents (mucus, etc.).

Obstruction of the sigmoid colon by a biliary calculus usually occurs secondary to pre-existing colonic disease such as diverticulosis or carcinoma, and usually occurs as the result of a calculus entering the colon by means of a cholecystocolonic fistula.

Calculi producing complete obstruction usually lodge in the terminal ileum, although large calculi can produce obstruction at any level. Cases of this type are very likely the least important from the diagnostic standpoint since surgery is ordinarily instituted at an early stage in cases of acute small intestinal obstruction at the present time.

Occasionally, the patient's age, obesity, or physical condition may preclude early surgical intervention in spite of a clinical and roentgen impression of a mechanical obstruction. Very often intubation and temporizing procedures are instituted much to the detriment of such a patient.

If a positive roentgen diagnosis of gallstone ileus is made, prompt surgical intervention is indicated before damage to the intestinal wall and its sequelae appear. It has frequently been stated that the single, most important factor affecting the mortality of this condition is the delay in diagnosis.

On occasion a calculus will lodge in the duodenal bulb and produce a clinical picture extremely difficult of diagnosis. Patients thus afflicted present signs of a high incomplete intestinal obstruction with the principal complaint being intermittent, recurrent attacks of vomiting, especially after ingestion of solid foods.

Since internal biliary fistulas are almost always due to perforation or erosion of biliary calculi, and occur most often between the gallbladder and first portion of the duodenum, we can assume that obturation of the duodenal bulb by a gallstone must occur in a variable number of such cases. Such obturation is more apt to occur in the initial phase of the disease, especially when the calculus is of large size.

We have had the opportunity to study 4 cases of gallstone obturation of the duodenal bulb and were impressed with the variability of the clinical features. In one case under our observation, the clinical findings, right upper quadrant pain, tenderness, and vomiting, were such that the referring physician considered them to be an exacerbation of a previously known cholecystitis and cholelithiasis. Cholecystograms revealed air in the biliary passages and a gastrointestinal study was advised. This, to our surprise, demonstrated a completely unanticipated obturation of the duodenal bulb by a huge gallstone and the expected cholecystoduodenal fistula. A second case of this type presented herself with hematemesis, upper abdominal pain, and tenderness. These symptoms were construed as representative of a perforating ulcer with hemorrhage.

A third case, discovered accidentally, revealed that twenty-one days prior to admission to Grace Hospital, an upper gastrointestinal study done elsewhere revealed a huge, dilated stomach with marked gastric retention and a large persistent ovoid translucent defect within the duodenal bulb. Our survey film study of the abdomen at the time of admission permitted an impression of severe gastric dilatation and probable high small intestinal obstruction. At surgery four days later a gallstone was found in the distal ileum. An important lesson in this case is the fact that a large gallstone was present in the duodenal bulb for at least twenty-one days and produced minimal distress with vomiting and inability to tolerate solid foods as the principal complaints. Only when the calculus was dislodged into the small intestine and produced a complete obstruction were the patient's complaints considered sufficiently serious to warrant hospitalization.

An intermediate group of cases present indefinite, vague findings suggestive of partial intestinal obstruction with remission and recurrence of distention, fullness, and vomiting. Inability to demonstrate significant roentgen evidence of obstruction, and the bizarre clinical picture may again lead to temporization, with the attendant serious consequences. In many cases of this type, especially when the calculus is impacted high in the gastrointestinal tract, the only evidence of the nature of the pathologic process may be in

the roentgen demonstration of biliary air, or in the demonstration of an aberrantly located opaque biliary calculus.

ROENTGEN DIAGNOSIS

Minimum studies of the acute abdomen at our hospital usually consist of anteroposterior and upright films. Decubitus, transabdominal views, or contrast studies are carried out only if a survey of the preliminary films and a review of the clinical findings indicate the necessity of such studies.

The most important roentgen sign in cases of gallstone obturation is the demonstration of air in some portion of the biliary tree. Demonstration of an obstructive ileus in the presence of biliary air must lead one to the assumption of gallstone ileus. The combination of obstructive ileus and an aberrantly located biliary calculus should, for practical purposes, be considered diagnostic of gallstone obstruction. In such cases a careful survey of the right upper quadrant will frequently show evidence of air in some portion of the biliary tree. This combination of findings—obstructive ileus, biliary air, ectopically located biliary calculus—must be considered pathognomonic of gallstone obstruction.

Suspicion of biliary air in any given case merits a review of past survey or cholecystographic studies, if such are available, since occasionally an opaque biliary calculus or calculi previously visualized may show change in position, rotation of the long axis of a large, ovoid calculus from a vertical to a horizontal plane, or complete disappearance from the right upper quadrant.

Disappearance of a biliary calculus from the right upper quadrant is an extremely significant roentgen finding which must lead one to the assumption of an internal biliary fistula. In the presence of obstruction, the evidence points irrevocably to a gallstone obstruction. In such cases, a careful survey of the films may be necessary to localize a calculus which is heavily calcified and readily seen in the right upper quadrant, but outlined with considerable difficulty if it overlies heavy bone structures, especially the sacral areas.

We have, in our collection, 3 cases in which a gallstone was identified in the gallbladder area during the acute phase of the illness on survey film studies, or on earlier survey or cholecystographic studies. These cases subsequently developed ileus and change in position of the previously noted calculus while under observation.

We feel that a transverse or horizontal orientation of the long axis of an ovoid, opaque biliary calculus medially located in the upper right or mid-abdomen is an extremely significant roentgen sign suggesting obturation of the duodenal bulb and we have written a separate paper to illustrate and emphasize this finding (see Case 2).*

Ingestion of barium is ordinarily contraindicated in cases of gallstone obturation, especially in those with roentgen evidence of ileus. Occasionally, the accidental or purposeful administration of a barium meal may result in the visualization of a calculus by this method.

It is our opinion that in all cases, irrespective of the acuteness of the patient's condition, in which there is supicion of biliary air and no roentgen evidence of ileus, the supicion of an internal biliary fistula should be confirmed by a contrast meal. If these studies are negative, contrast examination of the colon should be done, since occasionally a cholecystocolonic fistula will be present. Only by this means can one arrive at a correct interpretation of the pathologic process which has ensued. As previously mentioned, application of this rule in one case led to the discovery of a huge calculus which was impacted in the duodenal bulb.

We believe that in cases in which the roentgen evidence of ileus is minimal, nonexistent, or changing markedly in degree on repeated studies in which the presence of biliary air is ascertained, the administra-

* "Gallstone obturation of the duodenal bulb. To be published in *Radiology*.

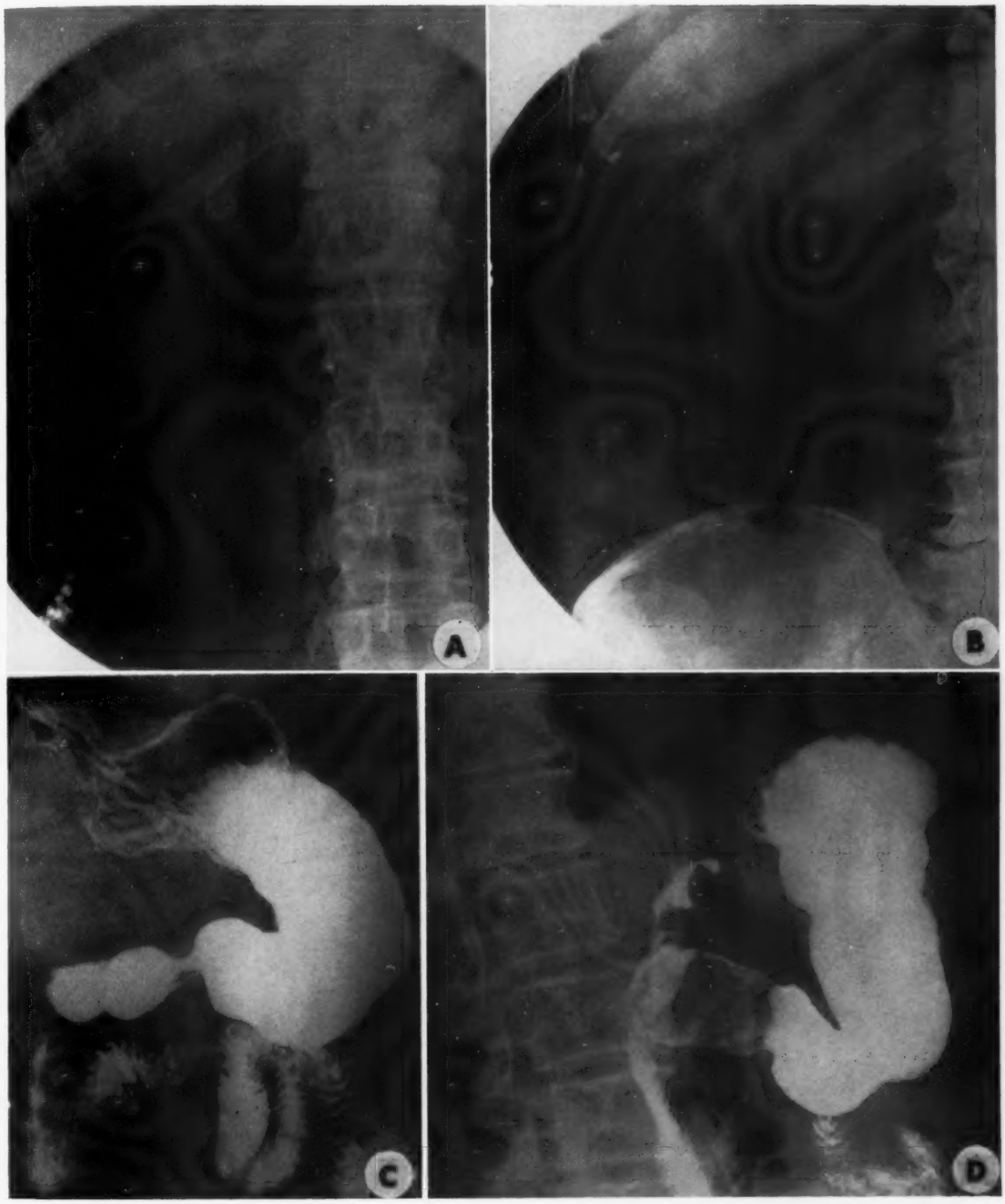

Fig. 1. Case 1. (*A*) Cholecystographic study in 1948. Note especially two small laminated calculi within a poorly visualized gallbladder and the large nonopaque stone. (*B*) Note tubular columns of gas in the biliary area and disappearance of the calculi noted on (*A*). (*C*) Normal upper gastrointestinal study in 1948. (*D*) Large negative defect in the pyloroduodenal area and barium filling of the cholecystoduodenal fistula.

tion of a dilute barium meal is a safe diagnostic procedure. This is especially true if a decompression tube has been passed and may permit accurate evaluation of the pathologic process. Cases of high small intestinal obstruction often present little or no roentgen evidence of obstruction. The clinical findings may be extremely unreli-

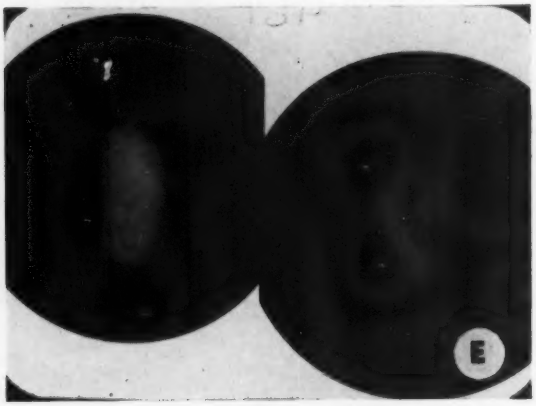

FIG. 2. Case 1. (*E*) Roentgenograms of the gallstone which was removed from the duodenal bulb at surgery.

able, especially if the obstruction is incomplete.

Administration of a barium meal permitted a correct, early diagnosis of gallstone obstruction in 3 cases in our series (Cases 1, 2 and 6) which could not have been accurately differentiated by any other method. Case 3 constitutes an error of interpretation, actually a fourth case, the preoperative diagnosis of which would be possible only after the administration of a barium meal.

Roentgen criteria for the diagnosis of gallstone obturation are classified as follows:

(A) Gallstone obturation with roentgen evidence of ileus.
  1. Demonstration of biliary air.
  2. Ileus.
  3. Visualization of calculus.
    (a) Opaque—aberrantly located biliary calculus.
    (b) Nonopaque—accidental or purposeful ingestion of barium.
  4. Change in position of calculus.
    (a) From right upper quadrant—disappearance of calculus from right upper quadrant as evidenced from study of earlier films.
    (b) Within the abdominal cavity on progress studies—after development of ileus.

(B) Gallstone obturation without reliable roentgen evidence of ileus.
  1. Demonstration of biliary air.
  2. Visualization of calculus.
    (a) Opaque
      (1) Transverse of horizontal orientation of the long axis of an ovoid, opaque calculus medially located in the upper abdomen, should suggest obturation of the duodenal bulb.
      (2) Aberrantly situated, opaque biliary calculus.
      (3) Change in position of calculus on progress studies.
    (b) Nonopaque—by means of contrast medium.

REPORT OF CASES

CASE 1. M.C., a white female, aged eighty-six, was admitted on March 2, 1953, with vomiting of two weeks' duration. Three weeks prior to admission the patient noticed onset of steady, dull aching pain in the epigastrium.

Patient had multiple previous hospital admissions with roentgen evidence of a poorly functioning gallbladder and cholelithiasis.

Roentgenographic Examination.

March 9, 1953: Cholecystographic examination revealed an extremely poorly functioning gallbladder with evidence of a large nonopaque calculus. Streaky, linear columns of air in the hepatic area suggested biliary air and the possibility of an internal biliary fistula. Review of cholecystographic studies of 1948 demonstrated that two small laminated calculi had disappeared in the interval between examinations. The suspicion of an internal biliary fistula was thus strengthened and an upper gastrointestinal study recommended. Clinical impression at this stage was acute cholecystitis and cholelithiasis.

March 11, 1953: Upper gastrointestinal study demonstrated a biliary fistula between the gallbladder and duodenum and a huge, radiolucent calculus which was impacted in the duodenal bulb. Barium emptied into the distal small intestine without undue difficulty.

Because of the patient's age and a known cardiac condition, surgery was delayed. Readministration of a barium meal on March 17, 1953, demonstrated no change from the earlier study.

Surgical exploration, March 19, 1953. A large calculus measuring 6 by 3.3 by 3 cm. was found impacted in the pyloroduodenal portion of the gastrointestinal tract. The calculus was easily displaced into the stomach and removed through a gastrotomy. The gallbladder could not be identified, and no further attempt at

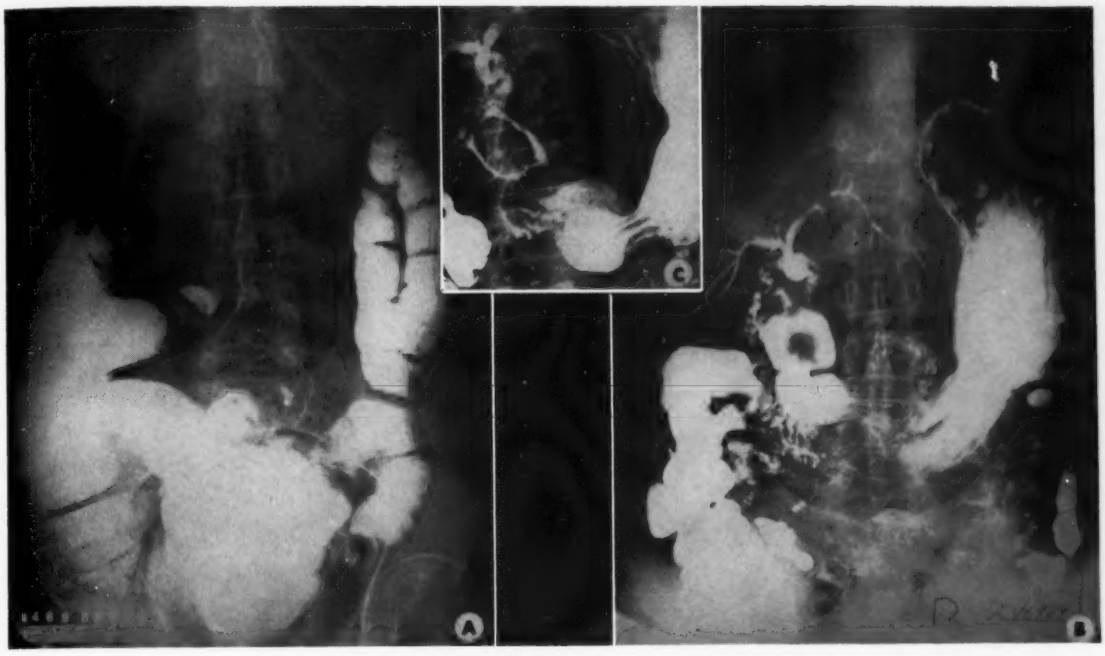

Fig. 3. Case 2. (*A*) Note tubular column of air in the right upper quadrant outlining the common duct and the ovoid calculus to the right of L-2 with the long axis of the stone being transverse. (*B*) Barium outlines the biliary tree and a gallstone fills the duodenal bulb. (*C*) Oblique study of the stomach and duodenum demonstrates more clearly the large stone impacted in the duodenal bulb.

Fig. 4. Case 3. (*A*) Note laminated gallstone to right of L-2 and 3 and the transverse orientation of the long axis of the stone. (*B*) Note change in position of the calculus and outline of the second portion of the duodenum by gas.

surgery was done. Patient recovered uneventfully and was discharged April 2, 1953.

Comment. Demonstration of biliary air and the recommendation of a contrast meal led to an unanticipated demonstration of gallstone obturation in the pyloroduodenal area.

On the insistence of the radiological department the patient was explored; the gallstone removed; the patient cured.

Suspicion of biliary air on survey or cholecystographic studies merits study of the gastrointestinal tract for confirmation of an internal biliary fistula. In the presence of vague, indefinite findings suggestive of incomplete obstruction the administration of a contrast meal may permit detection of gallstone obturation not accurately determinable by any other method.

Case 2. S.S., a white female, aged sixty-six, was admitted on June 1, 1943, with severe right upper quadrant pain, nausea, and vomiting of four to five days' duration. The patient vomited a small amount of blood shortly after the onset of pain.

Roentgenographic Examination.

June 1, 1953: Cholecystographic studies revealed a nonfunctioning gallbladder and an ovoid, laminated calculus 3 by 2.5 cm. in size, superimposing the transverse process of L-3 on the right.

June 2, 1953: Barium enema examination revealed a normal colon. The calculus was again visualized with the long axis of the calculus being transverse.

June 3, 1953: Upper gastrointestinal study revealed the gallstone to be impacted in the duodenal bulb with barium outlining a cholecystoduodenal fistula and filling the biliary radicles.

Course. Exploratory operation on June 3, 1953, confirmed the roentgenologic impression. A calculus was removed from the duodenal bulb following enterotomy; a drainage tube was placed in the gallbladder. Following an uneventful postoperative course the patient was discharged.

Comment. Note the presence of biliary air on the barium enema study; the location of the lamellated calculus, and the transverse orientation of the long axis of the gallstone. Generally speaking, the latter finding should suggest an abnormally situated gallstone and warrants contrast examination of the gastrointestinal tract to exclude the possibility of gallstone obturation.

Case 3. F.P., a white female, aged eighty-eight, was admitted on March 23, 1950, with cramping upper abdominal pain, nausea and vomiting of four days' duration. No history of past surgery or of previous illness.

Roentgenographic Examination.

March 23, 1950: Anteroposterior and upright studies of the abdomen revealed a laminated calculus 3 by 4.5 cm. in size, adjacent to the transverse process of L-3, on the right with the long axis of the calculus being horizontal. No conclusive evidence of biliary air or of ileus.

March 25, 1950: Repeat examination of the abdomen revealed findings identical to studies of March 23, 1950.

March 28, 1950: Barium enema examination revealed a normal colon. At this time on the post-evacuation study, considerable gas outlined the second portion of the duodenum proximal to the calculus. There was also a change in long axis of the calculus between the pre- and post-evacuation studies.

Course. During the period of hospitalization the patient continued to vomit, especially after ingestion of solids. Only after the barium enema examination was it realized that a gallstone was impacted at the junction of the second and third parts of the duodenum. In retrospect, there was vague evidence of biliary air on the earlier studies.

Exploratory operation on March 29, 1950, confirmed the presence of a calculus in the duodenum which was removed following enterotomy. The patient recovered and was discharged on April 5, 1950.

Comment. In spite of a high grade obstruction of the duodenum by a biliary stone, the roentgen evidence of ileus proximal to the calculus was non-existent on repeated studies. Only on the occasion of the barium enema, and then only on the post-evacuation study, was gas outlined proximal to the obstruction. Undoubtedly, persistent vomiting prevents accumulation of appreciable quantities of gas, al-

though accumulation of fluid may cause obliteration of distended small intestinal loops.

More important in this case, and perhaps of some diagnostic importance, is the orientation of the calculus. In this case the long axis of the calculus was horizontal. Ordinarily, normally situated gallstones of this size and shape are orientated with the long axis in a vertical direction.

Case 4. A.L., a white woman, aged thirty-four, eight and a half months pregnant, was admitted on January 18, 1953, with severe upper abdominal pain and vomiting. Symptoms persisted and on the second hospital day she was delivered of a normal child. After the delivery she felt temporarily improved; however, vomiting recurred with persistence of upper abdominal pain and some distention being noted on the fifth hospital day.

Survey film study of the abdomen on January 23, 1953, revealed severe distention of the proximal small intestine and stomach with a large opaque calculus, measuring 3.5 by 5 cm., being located to the right of the transverse processes of L-3 and L-4.

Surgical exploration revealed a gallstone impacted in the distal jejunum which was removed following enterotomy. The gallbladder was removed and a cholecystoduodenal fistula with an opening of 1 cm. was repaired. Patient was discharged on February 3, 1953.

Comment. The presence of an opaque calculus and obstructive ileus are sufficient for a specific diagnosis in this case. A small tubular air column is seen through the gas-filled duodenal bulb and very likely outlines the fistula.

Case 5. V.S., a white female, aged sixty-seven, was admitted on March 11, 1946, complaining of nausea and vomiting of two weeks' duration; abdominal pain of one and a half weeks duration.

Because of a language difficulty the history was obtained from a daughter who stated that her mother had been perfectly well all of her life until two weeks ago when she suddenly became nauseated and vomited a dark green, bitter material. Vomiting persisted for three days and the patient improved slightly after receiving some medication. After two days of relief, symptoms recurred with development of generalized abdominal pain. No bowel movements after the second day of illness.

Fig. 5. Case 4. Note the gaseous distention of the proximal small intestine and the dense opaque calculus in the right mid-flank.

Physical examination revealed an apprehensive, acutely ill female, with abdominal distention, tenderness to palpation in the upper quadrants. Hyperactive peristaltic activity was audible.

Roentgenographic Examination.

March 11, 1946: Survey film study of the abdomen was interpreted as negative for evidence of obstruction. Note vaguely visualized columnar air shadows in the right upper quadrant and faintly lamellated calculus which superimposed left iliac bone.

March 13, 1946: Studies of the lower and upper gastrointestinal tracts revealed a complete obstruction at the jejunum with barium outlining a large calculus in the left lower quadrant. A small amount of barium had entered the fistulous communication between the gallbladder and duodenum

Surgical exploration on March 13, 1946, revealed a large gallstone, 4 by 5 cm. in size, impacted in the distal jejunum with considerable

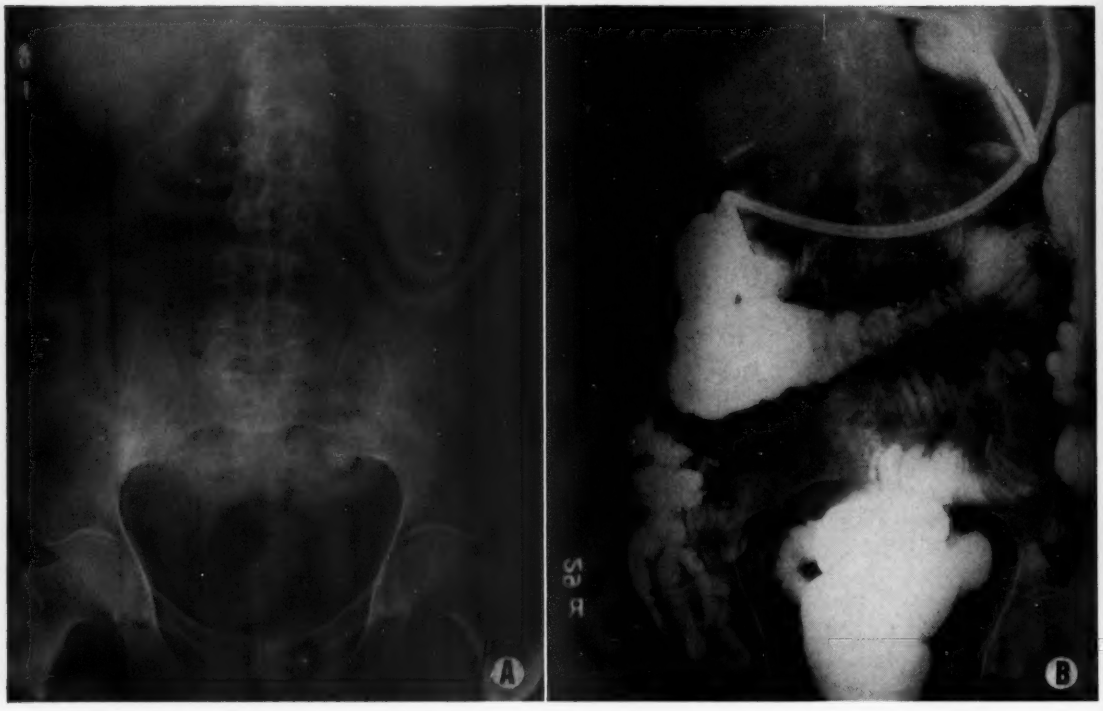

FIG. 6. Case 5. (*A*) Faintly visualized laminated calculus is seen to be superimposed on the left iliac bone adjacent to the sacroiliac joint. Faintly visualized tubular air shadows are present in the right upper quadrant. (*B*) Note the location of the calculus in the jejunum overlying the left iliac bone as outlined by a contrast meal.

dilatation of intestine proximally. The calculus was removed following enterotomy. The patient died on March 14, 1946.

Comment. The long delay on the part of the patient in seeking medical care undoubtedly played an important role in her demise. Death was primarily due to generalized debilitation and cardiac failure consequent upon her prolonged illness.

There was no roentgen evidence of obstruction on the scout study in spite of a complete block in the distal jejunum. Most likely, fluid accumulation obliterated gas distended loops proximal to the obstruction (necessity of upright studies); however, not infrequently with high obstructions persistent vomiting will prevent accumulation of roentgenographically identifiable quantities of gas.

CASE 6. A.G., a white female, aged sixty-seven, was admitted on June 20, 1939, with epigastric pain and vomiting. Onset of symptoms five days ago, with nausea followed by vomiting at time of admission.

Roentgenographic Studies of the Abdomen.

June 20, 1939: A large laminated calculus was demonstrated in the right upper quadrant. No other abnormalities.

June 22, 1939: The large calculus had disappeared from the right upper quadrant. Multiple tubular columns of air are present in the liver area. Unreliable roentgen evidence of ileus. The calculus can be identified over the body of the sacrum slightly to the left of the midline.

July 17, 1939: The calculus was identified in the right lower quadrant with evidence of severe obstructive ileus at this time. A diagnosis of gallstone ileus was made.

Surgical Exploration. July 20, 1939: Large calculus removed from terminal ileum. Patient died on July 26, 1939.

Comment. An exact pathologic diagnosis was possible on the second day of this patient's hospitalization. Disappearance of gallstone previously outlined in the right upper quadrant on the admission study

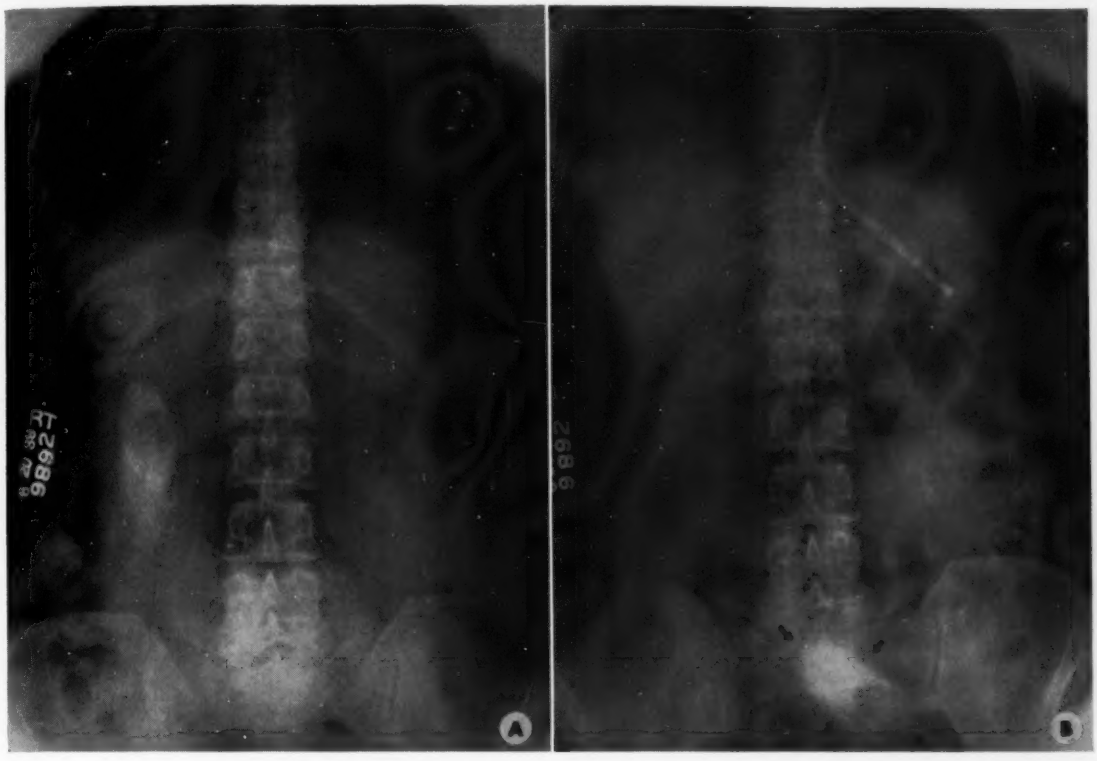

Fig. 7. Case 6. (*A*) Large laminated calculus is present in the gallbladder area. (*B*) The calculus has changed position and now is superimposed on the body of the sacrum. Note tubular gas shadows in the right upper quadrant and indefinite roentgen findings of intestinal obstruction.

should have aroused the interpreter's imagination. Close observation of this film permits identification of biliary air and a change in the position of the calculus. The absence of roentgen evidence of ileus does not exclude the possibility of intestinal obstruction.

A roentgen diagnosis of gallstone obstruction was made on July 17, 1939, exactly twenty-five days later than it should have been. The patient's death can only be attributed to this marked delay in diagnosis.

Case 7. L.K., a white female, aged sixty-six, was admitted with severe, sharp, constant umbilical and epigastric pain of eighteen hours' duration with hematemesis.

Past history revealed no evidence of fatty intolerance. Patient had experienced postprandial distress during the last five to six years which had been relieved by ingestion of soda.

Physical examination revealed epigastric tenderness; minimal abdominal distention with audible peristaltic activity. Clinical impression: Probable peptic ulcer with hemorrhage and incipient perforation.

Roentgenographic Examination.

September 15, 1949: Anteroposterior and upright studies of the abdomen revealed no evidence of ileus and a vaguely visualized laminated gallbladder calculus in the right upper quadrant.

September 22, 1949: A barium meal administered accidentally revealed a fistulous communication between the first portion of the duodenum and the gallbladder, and moderate distention of the major portion of the small intestine. At the four hour study a nonopaque calculus was outlined in the terminal ileum by the contrast meal. A long tube was passed and it was decided that the barium should be removed before surgery was carried out.

September 25, 1949: Survey film study of the abdomen revealed complete aspiration of the barium. Air clearly outlined the common duct and biliary tree.

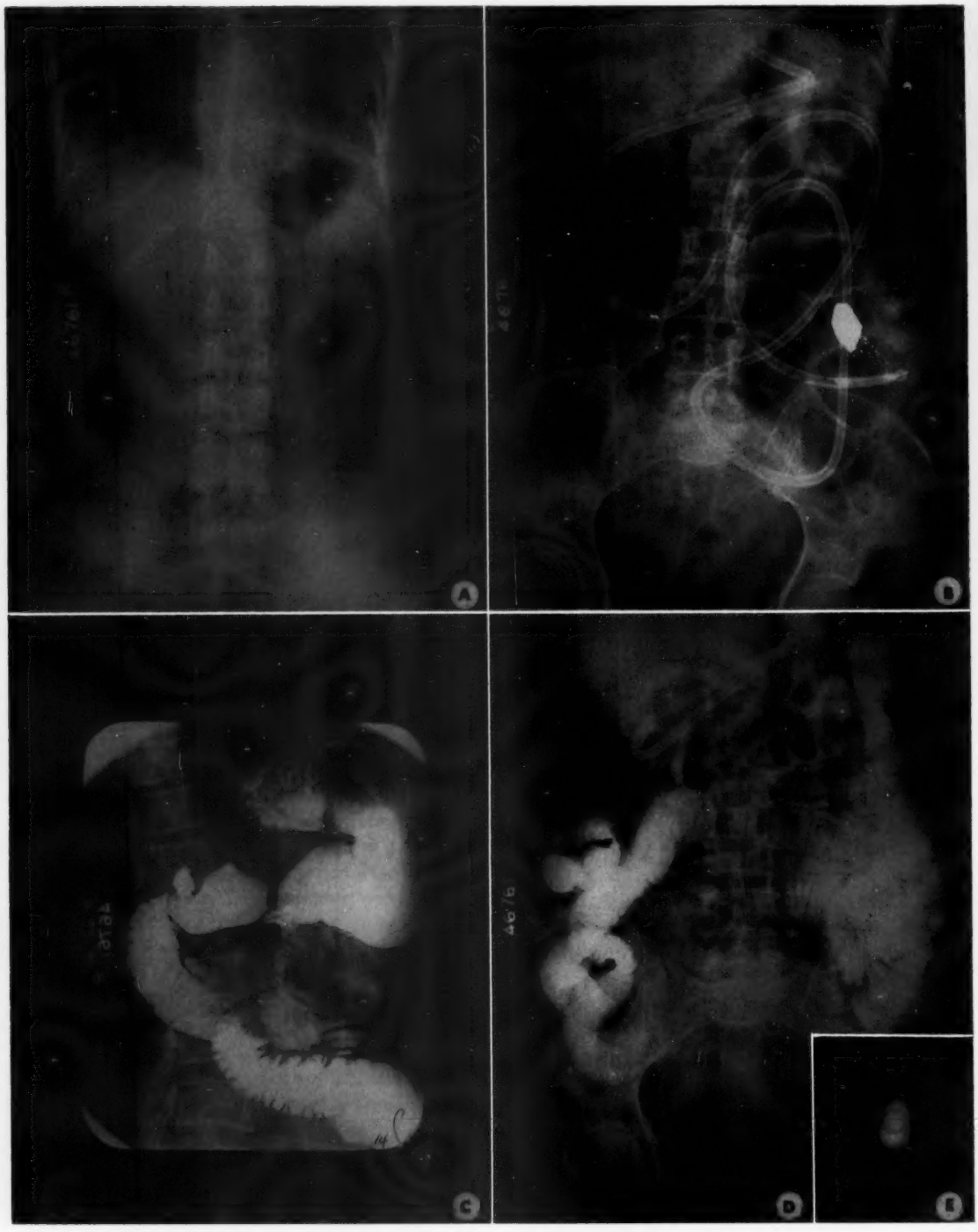

FIG. 8. Case 7. (*A*) Faintly visualized laminated calculus is seen to superimpose the superior pole of the right kidney. (*B*) Note the clear delineation of the common duct and biliary tree by gas and the obstructive ileus. (*C*) Barium outlines the cholecystoduodenal fistula. (*D*) The nonopaque stone is outlined by barium at the four hour study in the right mid-flank. (*E*) Roentgen examination of the pathologic specimen.

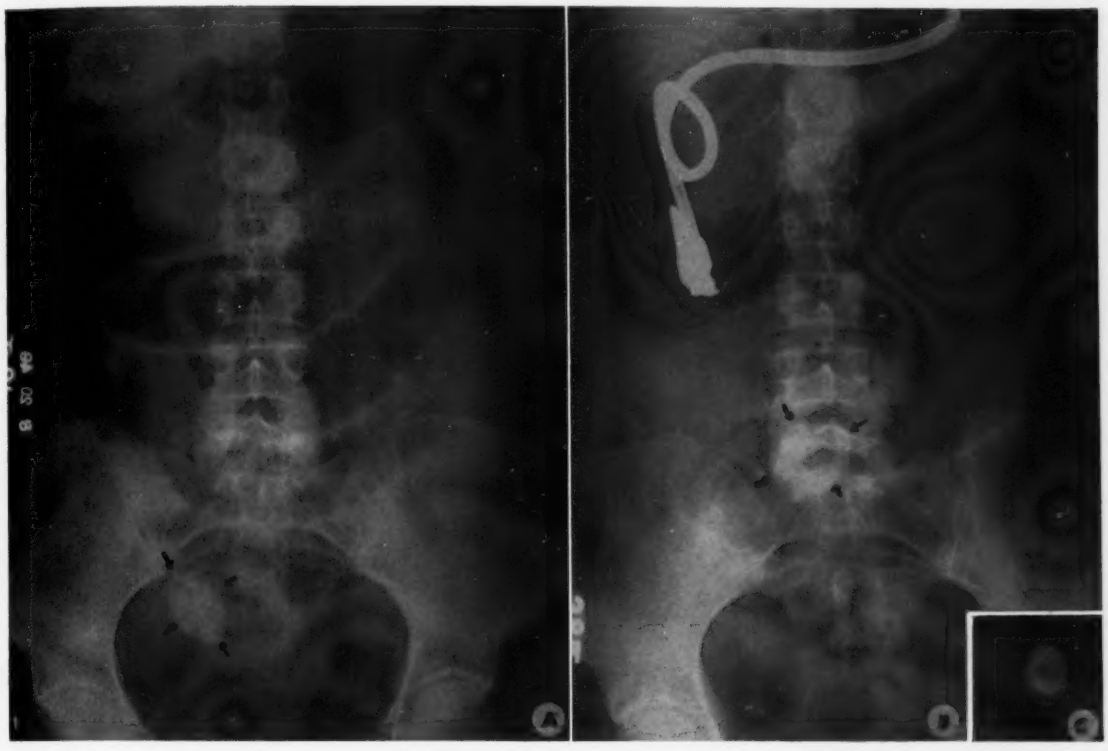

Fig. 9. Case 8. (*A*) Note the opaque calculus to the right of the body of the sacrum and obstructive ileus. (*B*) The calculus has changed position and now overlies the body of L-5. Note tubular gas shadows in right upper quadrant on this study. (*C*) Roentgenogram of the gallstone which was removed at surgery.

Comment. Initially the clinical features suggested a perforating, hemorrhaging peptic ulcer. The preliminary survey studies localized a normally situated gallstone and no other pathologic change. A barium meal administered accidentally demonstrated conclusive evidence of gallstone ileus. Prior to surgery a survey film study of the abdomen revealed a beautiful delineation of the common duct and biliary tree and obstructive ileus; a combination of features which should have permitted an accurate, preoperative diagnosis prior to the administration of barium.

Case 8. M.H., a white female, aged fifty-seven, was admitted on August 17, 1949, with upper abdominal pain, nausea and vomiting of one week's duration, obstipation for four to five days. Symptoms increased in severity, especially the vomiting.

Roentgenographic Examination.

August 20, 1949: Survey film of the abdomen interpreted as obstructive ileus involving the small intestine. Laminated calcification noted in pelvis to right of sacrum.

August 22, 1949: Calculus had shifted position to overlie L-5. Again there was evidence of obstructive ileus.

Surgical exploration on August 22, 1949, revealed a gallstone measuring 3.5 by 2.5 cm. removed from distal ileum. Patient discharged on August 29, 1949.

Comment. Note position of vaguely identified calculus in right lower quadrant on initial study; its change of position on second study; obstructive ileus. Findings are adequate for diagnosis of gallstone ileus. Note incidentally tubular columns of air in right upper quadrant indicating presence of biliary air. This combination of features constitutes a pathognomonic triad.

Case 9. A.L., a white female, aged seventy-six, was admitted on March 19, 1952, with right

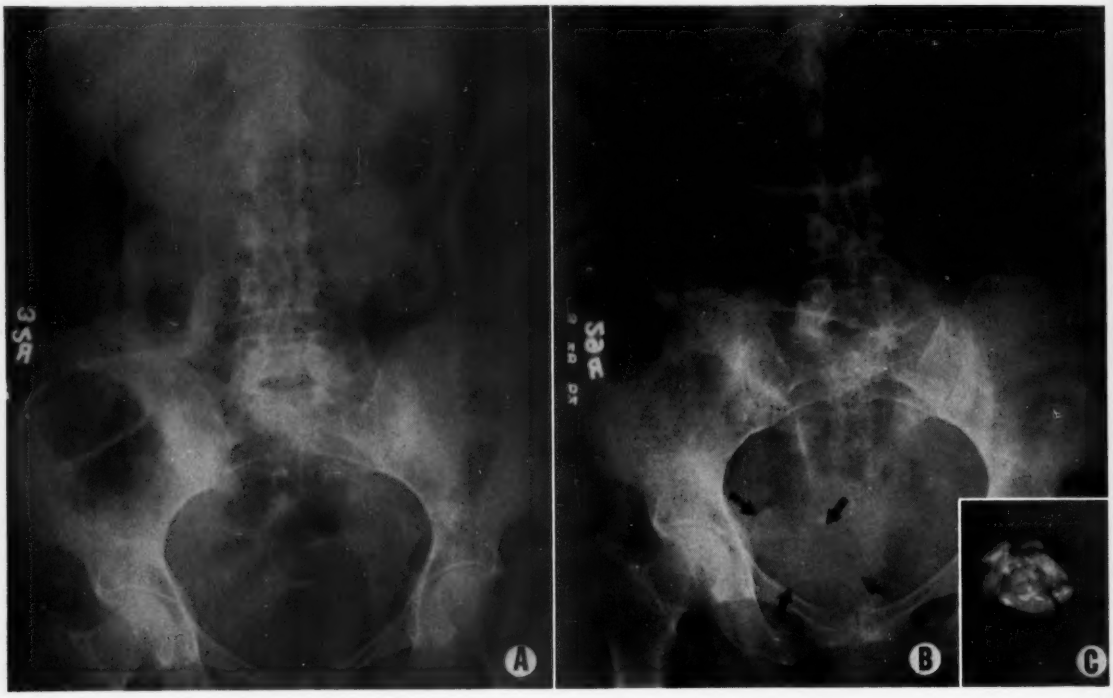

Fig. 10. Case 9. (*A*) Preliminary roentgenogram of the abdomen prior to development of gallstone ileus. Note indefinite, vague calcifications in right mid-flank. (*B*) Note ovoid mass deep in the right pelvis with indefinite calcification, obstructive ileus and Y-shaped gas shadow in right upper quadrant. (*C*) Roentgenogram of calculus removed at surgery.

upper quadrant pain, nausea and vomiting. Patient has had known gallbladder difficulty and refused surgery one year ago.

Roentgenographic Examination.

March 19, 1952: Anteroposterior and upright studies of the abdomen revealed no evidence of ileus. Suspicion of opaque calculi in the right upper quadrant which was partially obscured by gas and fecal content in the colon.

March 20, 1952: Considerable abdominal distention was present and re-examination of the abdomen revealed evidence of a high grade mechanical obstruction involving the small intestine with the probable site of obstruction being in the proximal or mid-ileum. A "Y" shaped column of air was present in the right upper quadrant. An ovoid shaped mass was seen in the right lower quadrant with vaguely visualized irregular calcifications within this mass.

Surgical Exploration. March 26, 1952: A large gallstone the size of an egg was impacted in the proximal ileum and had resulted in a complete obstruction of the small intestine. The intestine at the site of the impaction was necrotic and as such a resection with end-to-end anastomosis of small intestine was done. Postoperatively the patient's course was complicated by evisceration and leakage at the anastomosis. Following a second operation the patient developed cardiac failure and died on April 9, 1952.

Comment. At the time of admission the clinical findings were consistent with an inflammatory process in the upper abdomen without roentgen or clinical evidence of ileus. While hospitalized the patient developed an obstructive ileus. The progress survey film studies demonstrated the classical triad: biliary air, obstructive ileus, and an abnormally situated calculus.

The death of this patient is unfortunate; however, to some extent it may be attributable to the development of gangrene at the site of impaction of the calculus with more extensive surgery being required as a result. Closer follow-up studies in the interval between the time of admission and the development of obstruc-

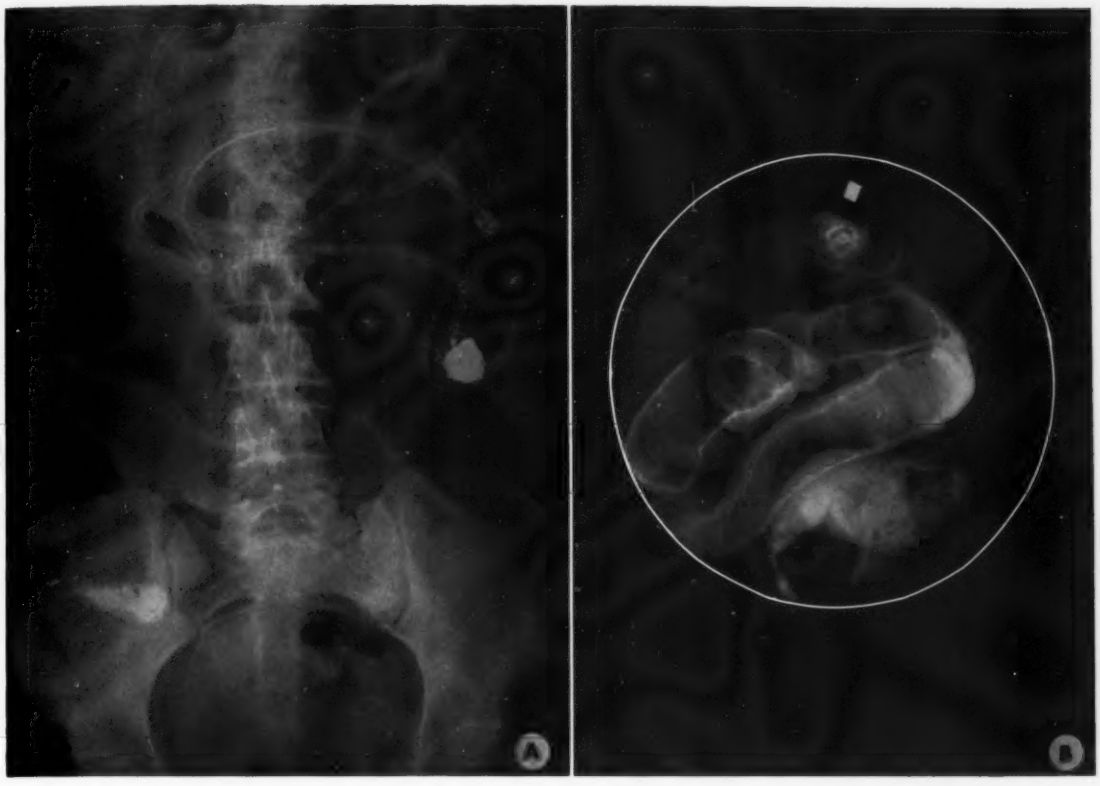

Fig. 11. Case 10. (*A*) Note the columnar gas shadow high in the right upper quadrant and obstructive ileus. (*B*) Autopsy specimen demonstrating calculus in the terminal ileum.

tion might have prevented this complication.

Case 10. M.C., a white female, aged fifty-five, admitted in a disoriented state. History of epigastric pain, ten days of nausea, vomiting and obstipation seven days. Under care of local doctor for gallbladder condition during present illness. Due to patient's condition, surgery was not deemed advisable and she was treated with a decompression tube. Patient died two days after admission. Autopsy demonstrated complete obstruction of the terminal ileum by a large gallstone. A fistulous communication between the gallbladder and duodenum was noted, and a second fistula between the gallbladder and colon was occluded by another large gallstone.

Comment. The survey film of the abdomen at the time of admission permits an unequivocal diagnosis of gallstone obstruction. Note the tubular column of air in the biliary area and obstructive ileus. The findings indicate the necessity of early surgical intervention.

Case 11. H.K., a white female, aged sixty-two, was admitted on September 26, 1938, with abdominal pain, distention, nausea and vomiting of four days' duration.

Roentgenographic Examination.

September 26, 1938: Survey film of the abdomen revealed a complete mechanical obstruction involving the entire small intestine with a laminated calculus measuring 1.2 by 1.7 cm. at the ileocecal area. Impression: Gallstone obstruction of terminal ileum.

Surgery. A gallstone was removed from the terminal ileum following an ileostomy. Patient recovered gradually and was discharged on October 12, 1938.

Comment. The presence of a laminated calculus and severe obstructive ileus constitute in many cases sufficient evidence to warrant the diagnosis of gallstone ileus. Occasionally an appendicolith complicating

Fig. 12. Case 11. Note laminated calculus in the ileocecal area and obstructive ileus.

a ruptured appendix may simulate this picture but should be readily differentiated on a clinical basis.

Case 12. S.D., a male, aged sixty-five, was admitted on November 28, 1949, with upper abdominal pain, nausea and vomiting. Onset of symptoms three days prior to admission.

Roentgenologic Study.

November 28, 1949: Survey film study of the abdomen revealed evidence of multiple small laminated calculi in the ileocecal area and in the right upper quadrant. Moderately distended loops of small intestine were present in the upper abdomen and the transverse colon appeared to be outlined with gas.

November 30, 1949: Survey film study revealed at least six small, laminated calculi in the course of the ascending colon with moderately severe inflation of small intestinal loops throughout the abdomen. Gaseous distention of the transverse and descending colon was present.

Impression. Partial intestinal obstruction due to gallstones with calculi being present in the ascending colon.

Fig. 13. Case 12. (*A*) Note multiple laminated calculi in the right mid-flank and right upper quadrant. (*B*) Note multiple calculi in the course of the ascending colon. (*C*) Roentgenogram of calculi which were recovered in the stool of this patient.

Course. The patient passed multiple calculi in the stool during the next twenty-four to forty-eight hours. An upper gastrointestinal study was done on December 5, 1949, which revealed a cholecystoduodenal fistula but no other abnormalities.

Comment. Multiple small gallstones traversed the entire gastrointestinal tract and produced minimal partial small intestinal obstruction.

CONCLUSIONS

An evaluation of the cases examined in this series indicated that a diagnosis of probable gallstone obstruction could be made from an analysis of the survey film studies in 10 of the 17 cases in our series (Cases 3, 4, 6, 7, 8, 9, 10, 11, 12, 14). A correct diagnosis was made in Cases 1, 2 and 5, only following the ingestion of a barium meal. Case 13 constitutes an error in interpretation; actually, then, the combination of studies permitted an accuracy of approximately 80 per cent correct diagnoses preoperatively of this very important form of mechanical obstruction.

Of the group of 17 cases, 5 patients died, a mortality of 29 per cent (Cases 5, 6, 9, 10, 15). Deaths of Cases 5 and 10 are attributable in great part to the delay on the part of the patient in seeking medical care.

The death of Case 6 is completely attributable to the failure of proper interpretation of obvious roentgenographic evidence of gallstone obstruction. Death of Case 15 is in part the responsibility of the radiologist who made a correct diagnosis of small intestinal obstruction, but who could have made a diagnosis of probable gallstone obstruction, and who then should have urged the surgeon to early operation. It is the responsibility of the radiologist to make as specific a diagnosis as is possible, and in cases of the above type, the consequence of delay in diagnosis, and ultimately of treatment, may eventuate in mortalities which otherwise might have been avoided.

Death of Case 9 was largely due to more extensive surgery which was necessary because of necrosis of the intestinal wall at the site of impaction of the gallstone.

SUMMARY

1. Gallstone obturation constitutes a form of mechanical obstruction which can be diagnosed preoperatively by the radiologist with considerable accuracy in a majority of cases.

2. The extremely bizarre clinical aspects of this condition are discussed.

3. Roentgen criteria pertinent to a diagnosis of this condition are discussed, classified, and a number of cases presented demonstrating the variability of the roentgen findings.

4. The importance of recognizing biliary air and its significance in cases of gallstone obturation is stressed, as is the necessity of barium studies in cases of suspected internal biliary fistula in which the roentgen evidence of obstruction is unreliable.

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ENDOCARDIAL FIBROELASTOSIS

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ENDOCARDIAL fibroelastosis is one of the common types of fatal heart disease in infancy. In spite of this fact, the radiological literature contains little on the subject, and the signs and symptoms have not been emphasizd in most textbooks.

Much of the confusion is due to the multiplicity of names attached to this disease. These include endocardial sclerosis, congenital subendothelial myofibrosis, congenital idiopathic hypertrophy of the heart, prenatal fibroelastosis, fetal endocarditis, endocardial dysplasia, elastic tissue hyperplasia, and others. We have chosen the term, endocardial fibroelastosis, as best describing this entity as suggested by Weinberg and Himelfarb.[20]

LITERATURE

According to Rauchfuss[17], the concept of endocardial fibroelastosis was introduced by Kreysig in 1816 under the term, fetal endocarditis. Stohr[19] credits Rokitansky with laying down rigid microscopic criteria for the establishment of this diagnosis.

Blumberg and Lyon[2] reported 25 of their own cases and reviewed the literature of 69 others. They selected their patients on the basis of a whitish coating of fibroelastic tissue on the endocardium. In every instance the fibrotic changes occurred on the walls of the left ventricle and, when more extensive, they involved the endocardium of the right side of the heart and that of the valves in addition. They did not exclude extension of the fibrous tissue into the myocardium or the presence of cellular infiltrate or necrosis, even though such lesions resembled interstitial myocarditis, which may be a separate disease. Certain associated congential anomalies were excluded, but patent ductus arteriosus and coarctation of the aorta were not excluded, provided that these lesions had not produced symptoms previous to the onset of acute cardiac failure.

Golper[8] has recently reported a case in the radiological literature.

Dennis, Hansen and Corpening[5] reviewed the clinical and necropsy findings in 149 cases. These authors state that there are three types of clinical manifestations. They have named them fulminating, acute and chronic. The fulminating type of disease occurred in 25 per cent. These infants were under six weeks of age and had been considered normal before an abrupt onset of dyspnea with cyanosis. Survival after onset was only a matter of minutes or hours, and an occasional crib death was reported. In a rare instance the infant was cyanotic and in cardiac failure at birth. In general, the younger the infant, the shorter the course.

The acute type made up 51 per cent of the total and was seen in infants between six weeks and six months of age. They had been considered to be in good health prior to an unexpected paroxysm of dyspnea with cyanosis, the initial attack sometimes being ascribed to aspiration or choking. Repeated paroxysms followed and between attacks irritability, anorexia, tachycardia and spasmodic coughing became increasingly apparent. A globular type of cardiomegaly was found on roentgenographic examination. The symptoms culminated in fatal syncope characterized by shock, respiratory distress and cyanosis not relieved by oxygen. Survival after onset was less than four weeks and averaged only fifteen days.

The chronic type occurred in the remaining 24 per cent. Usually involved were older infants and children, but, at times, symptoms were noted during the first six months of life. The characteristic onset was slow, with anorexia, irritability and de-

creased rate of growth in a previously well child. A spasmodic hacking cough, presumed to represent respiratory disease, usually appeared at some interval during the illness.

Gross[9] reported a case with stenosis of the mitral and aortic valves which strikingly resembled the rheumatic valvular disease of adult life. There was associated hypoplasia of the root of the aorta, rudimentary development of the left ventricular cavity, the presence of a large patent ductus arteriosus and marked diffuse parietal endocardial sclerosis of the left ventricle. He considered these lesions to be noninflammatory because of the lack of inflammatory residua.

Collier and Rosahn[3] reviewed 11 cases and added 2 of their own.

Cosgrove and Kaump[4] reported 6 cases and reviewed, in tabulated form, 50 cases from the literature. Almost all had cardiomegaly with dilatation and hypertrophy of the left or both ventricles. They suggested that illness of the mother during pregnancy may be a factor in the production of endocardial sclerosis in the infant and that the entity should be considered a form of congenital heart disease.

Sano and Anderson[18] reported a case, Lewis[15] reported 3 cases and Adams and Katz[1] reported 4 cases. These last authors believe that the disease can be diagnosed clinically. Letteer[14] reported 2 additional cases.

Prior and Wyatt[16] presented 8 cases and suggest that the term, endocardial dysplasia, be used. Chest roentgenograms nearly always revealed cardiomegaly and served to introduce heart disease as a diagnostic consideration. Dyspnea and cyanosis were not conspicuous until the terminal phase and digitalis sometimes seemed to produce a remission. When death did occur, after a few months or years, it was often unexpected, with sudden dyspnea and shock typical of the acute disease. In 85 per cent of those who had chest roentgenograms there was cardiomegaly of a globular or diffuse type. Pathologically, the left ventricle was involved in 98 per cent of their cases. Microscopic studies disclosed hyperplasia of the fibrous and elastic tissue components of the endocardium. The elastic processes frequently projected a short way into the myocardium. Calcification was common in the endocardium, myocardium, and especially in the papillary muscles. Vacuolization and apparent degeneration were sometimes seen in the myocardium. There was never leukocytic infiltration, Aschoff nodule formation, nor findings of an inflammatory lesion. The hyperplasia was most marked in the cases of valvular deformity but the valves were not always directly involved by the process.

Katz and Adams[12] reported a case with facial and pedal edema with abnormal serum proteins of 1.4 mg. per cent albumin and 2.2 mg. percent globulin. This unusual finding was thought to be due to impaired ability of the liver to fabricate proteins.

Weinberg and Himelfarb[20] reported 2 cases in consecutive siblings. They call attention to a monograph by Douglas P. Murphy of the University of Pennsylvania entitled "Congenital Malformations (1940)" who stated that according to his statistical analyses the same congenital defect tends to recur in siblings in more than 50 percent of instances. These authors suggest that the thickened endocardium interferes with the venous drainage of the myocardium, subjecting it to anoxemia and eventual dilatation and ultimate failure.

Dordick[7] reported 2 cases in consecutive siblings.

ETIOLOGY

The mechanism of production of the lesions remains unexplained. Explanations which have been advanced favor some inherent developmental defect which is probably inherited. Others include simple hyperplasia of aortic tissue with extension into the heart or heterotopic aortic tissue, disturbances of circulation, familial inheritance, functional fibroelastosis of the

endocardium secondary to weak cardiac musculature, myocardial degeneration, metabolic disorder of the cardiac tissue, elastic tissue hyperplasia of the endocardium, relation to illness of the mother during pregnancy, relation to an acute infectious disease and relation to a developmental defect. Anoxemia and premature development of the heart in the fetus may be a factor.

Dewitski[6] was able to produce minimal endocardial fibroelastosis in rabbit hearts by repeated injections of epinephrine hydrochloride.

Hill and Reilly[10] believe it to be a collagen disease.

Johnson[11] states that close scrutiny shows a common factor usually present. This consists of anoxia either due to the presence of a congenitally aberrant coronary artery arising from the pulmonary artery or anoxia possibly due to premature closure of the foramen ovale or atresia of the pulmonary artery or aorta or a combination of these factors. Valvular atresias in which stagnation anoxia develops is also mentioned by him.

Fig. 1. Case 1. Initial roentgenogram of the chest shows the gross cardiac enlargement principally to the left. The transverse diameter of the heart measures 8.3 cm. and the chest 12.7 cm. There is a small area of mottled infiltration in the right upper lung field which was interpreted as an early pneumonia. The patient was then two months of age.

REPORT OF CASES

Case 1. M.H. (B.C.H. Case No. T-6942), a white male, aged two months, was admitted for evaluation because of rapid and labored respiration, two attacks of cyanosis and frequent vomiting of his formula. Delivery was uncomplicated and the infant cried spontaneously at birth. Admission chest films showed gross cardiac enlargement, the transverse diameter of the heart measuring 8.3 cm. and the chest 12.7 cm. (Fig. 1). The left ventricle showed marked prominence and the esophagus was displaced posteriorly at the site of the left atrium. He was discharged as unimproved.

The infant was readmitted at twelve weeks of age for further study. At this time his pulse was 160, temperature 98.6° F., and respirations 40 per minute, and blood pressure 90/50. He was well developed, well nourished and breathing with much effort. The intercostal and subcostal areas were retracting and he was slightly cyanotic. There was a slight precordial bulge with an increase in the anteroposterior diameter of the chest. There was dullness present over the left posterior chest and breath sounds were diminished in this area. The heart was enlarged to percussion and the left border was 0.5 cm. outside the nipple line. There was a Grade 1, low pitched, soft systolic murmur at the third interspace in the left parasternal line. A few days later this murmur was heard in the back in the interscapular area. The liver was palpable 1.5 cm. below the right costal margin. Femoral pulses were palpable.

The laboratory finding at that time were as follows on admission:

Urine: Within normal limits on each six occasions.

Blood: Hg 13 grams, red blood cell count 4.23 million, white blood cell count 11,700, with 29 per cent segmented forms, 2 per cent band forms, 58 per cent lymphocytes, 2 per cent eosinophils, and 9 per cent monocytes.

Six weeks later the laboratory findings were as follows:

Hemoglobin 12.1 grams, red blood cell count 3.7 million, absolute eosinophil count 66, and two weeks later, 594.

Fig. 2. Case 1. Final roentgenogram of the chest again shows the gross cardiac enlargement principally to the left. The transverse diameter of the heart now measures 12 cm. and the chest 16 cm. Linear compression atelectasis is now seen in both upper lung fields. The patient was then twenty months of age.

Blood chemistry: Fasting blood glucose 69 mg. per cent, CO_2 30.2 mEq./l., chlorides 99 mEq./l. Blood culture was sterile.

Repeated electrocardiographic studies showed marked left ventricular hypertrophy with equivocal evidence of progressive myocardial disease. A cardiac catheterization study showed moderate elevation of right ventricular and pulmonary artery pressures with a 5 volume per cent difference between the pulmonary artery and femoral artery blood samples.

Because of the evidence of cardiac failure he was digitalized and placed on diminishing doses of cortisone.

There were several other admissions because of dyspnea. On his final admission he had a temperature of 100.6° F., pulse 108, respiration 20.

At this time his urine showed 25 mg. per cent albumin and many uric acid crystals. In spite of therapy, the temperature, pulse rate and respirations continued to climb. He became more cyanotic, developed a systolic gallop and enlargement of the liver to two fingerbreadths below the costal margin and died.

Autopsy Findings. Significant autopsy findings centered around the heart. The organ was greatly hypertrophied. It weighed 225 grams. The enlargement was diffuse with a little preponderance in the right ventricle. The myocardium was flabby and all the chambers dilated. The valves appeared normal. The most striking change was in the endocardium, which was greatly thickened, yellowish-gray in color and stood out in sharp contrast to the myocardium (Fig. 3). The thickening of the endocardium had brought about a partial loss of the normal surface configuration. The surface of the thickened endocardium was normally smooth and glistening. This change was preponderant in the left ventricle.

Other findings were secondary and included bilateral hydrothorax, pulmonary edema, and partial collapse of the lower portions of the left lung attributable to cardiac hypertrophy. The abdomen contained an estimated 300 cc. of ascites, and edema of the mesentery was marked. The liver and spleen were enlarged, with passive congestion. The kidneys were also congested.

Microscopic examination confirmed the gross findings. The picture of endocardial thickening with fibrous and elastic tissue, strictly limited and not involving the adjacent myocardium (Fig. 4), was very striking.

Case 11. C.C. (B.C.H. No. F-10543), a white female, aged six months, was admitted dead on arrival. There had been a previous admission at the age of three and a half months because of grunting and rapid respiration and the presence of an upper respiratory infection. Mongoloid facies were noted at that time. She was cyanotic but was relieved when in oxygen. The heart was grossly enlarged and there were booming sounds with a loud rumbling sound present along the entire left side of the sternum. Sharply demarcated infiltration in the right upper lobe was present which responded to therapy after six days.

A chest film (Fig. 5) showed cardiac enlargement with prominence of the pulmonary artery and an increase in the bronchovascular pattern.

Laboratory examinations disclosed the following: Red blood cell count 3.8 million, hemoglobin 12.5 grams per cent, white blood cell count 13,250, with 73 per cent granulocytes. The urine showed less than 5 mg. per cent of albumin and was otherwise negative.

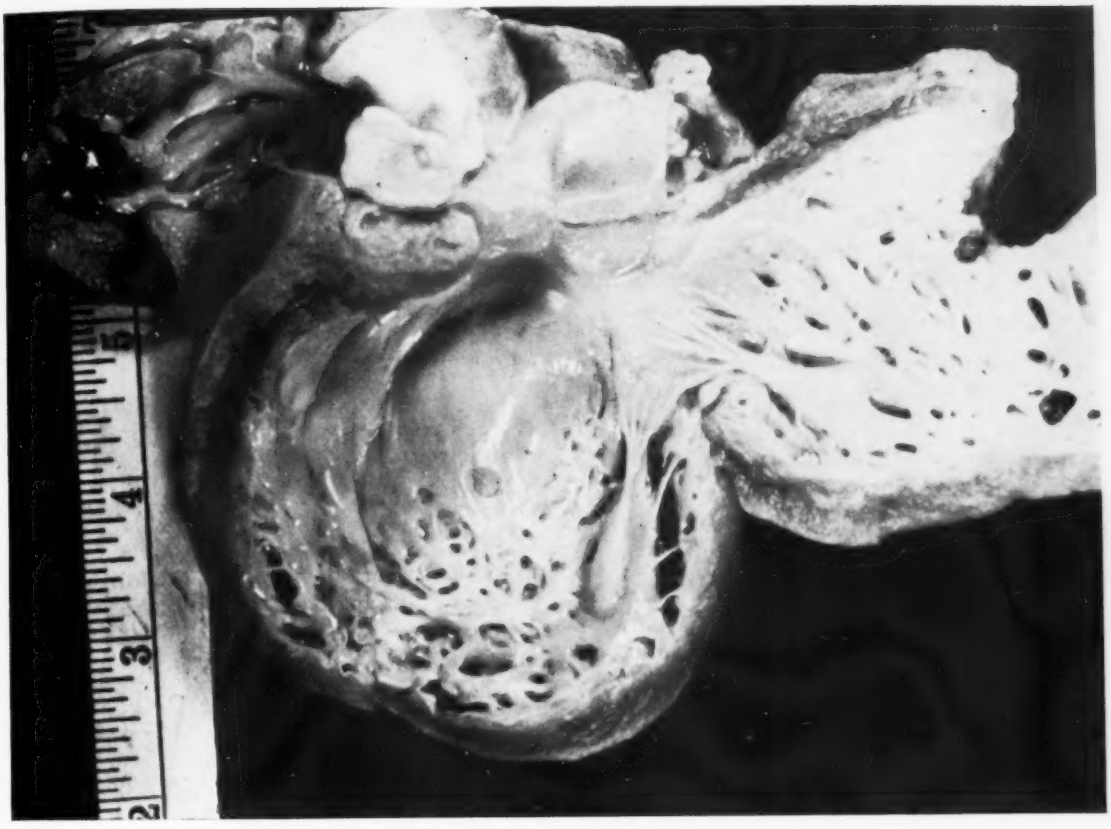

Fig. 3. Case 1. The heart is enlarged and dilated, the thickened pale endocardium standing out in sharp contrast to the muscle.

The infant was not seen again until she appeared at the Hospital dead upon arrival.

Autopsy Finding. Autopsy revealed an underdeveloped, somewhat malnourished white female infant, apparent age six months. The head was greatly enlarged and the anterior fontanel widely patent, thought soft. The facies were mongoloid in character. Generally throughout the body, there was evidence of cardiac decompensation with venous distention and edema of the tissues.

The heart weighed 51 grams and appeared enlarged with some left ventricular preponderance. The structure of the heart was essentially normal, but there was a widely patent ductus arteriosus. The myocardium was firm and the valves were essentially normal. The endocardium, lining the left ventricle, was thickened and yellowish-gray, standing out in sharp contrast to the myocardium. The papillary muscles also appeared thickened.

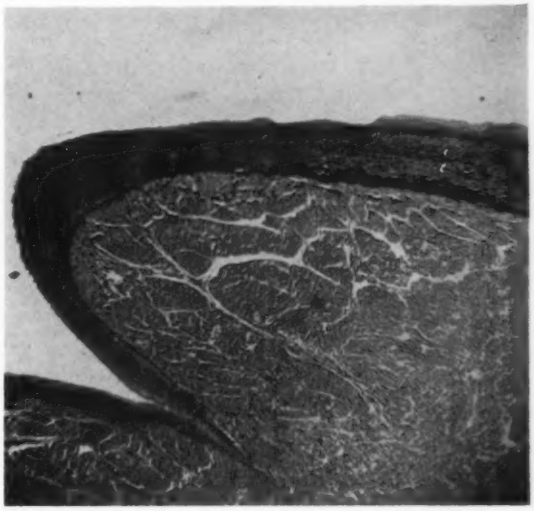

Fig. 4. Case 1. Photomicrograph (×30) of a portion of papillary muscle. The thick endocardial layer is stained dark by Weigert's elastic tissue stain.

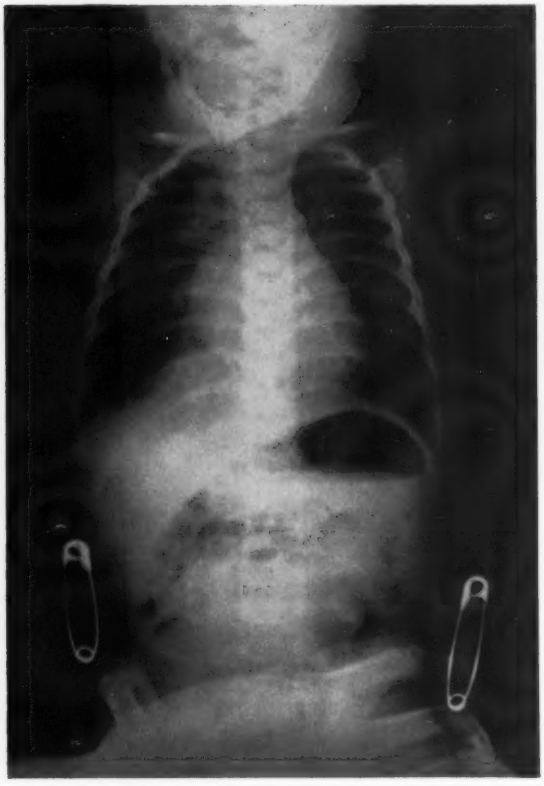

Fig. 5. Case II. A roentgenogram of the chest shows gross cardiac enlargement with slight prominence of the pulmonary artery and of the bronchovascular pattern. The transverse diameter of the heart measures 6.2 cm. and the chest 12 cm. There is an area of mottled infiltration in the right upper lung field.

The lungs were congested and edematous and both the liver and spleen showed degrees of passive congestion.

Although the intestinal tract appeared normal throughout, save for some curdled milk in the stomach, the entire mesentery was studded with large, soft, wet lymph nodes. The other organs appeared normal.

Microscopic examination confirmed the gross findings. The myocardium appeared normal, although thickened, and the endocardium stood out in sharp contrast, thickened with fibrous and elastic elements (Fig. 6). Sections of mesenteric lymph nodes revealed an advanced degree of reactive hyperplasia, but no other specific lesion. Congestive heart failure was considered the cause of death.

DISCUSSION

It is not often possible to make the diagnosis of endocardial fibroelastosis with

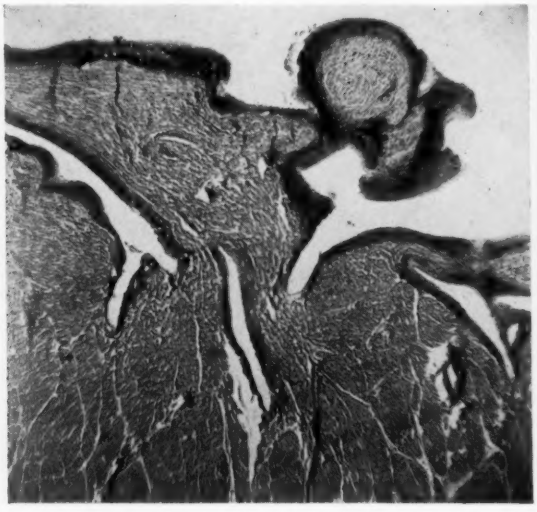

Fig. 6. Case II. Photomicrograph (×30) of endocardium and papillary muscles. Note that the endocardial thickening is not so advanced as in Case I.

certainty during life. Certain aspects of the reported cases have many features in common, however. Almost all had cardiac enlargement and, of these, almost all had left-sided enlargement, principally of the left ventricle. The responsibility for early diagnosis rests heavily upon the radiologist.

The clinical features fall into two patterns. The first is found in infants, usually less than six months of age, who have apparently been in good health until a sudden attack of severe dyspnea, cough, vomiting and tachycardia become manifest. The other group has episodes of mild dyspnea, with refusal to take food, vomiting, failure to gain weight and recurrent pulmonary infections. Murmurs are usually absent in this group. These usually have a fatal attack within two years.

Cyanosis in not a constant finding except in those cases which have involvement of the aortic valve which is an ominous sign.

The disease is probably congenital.

SUMMARY

Two additional cases of endocardial fibroelastosis have been presented. They were characterized by cardiomegaly, with attacks of dyspnea and cyanosis with eventual death. Hyperplasia of the fibrous and elastic components of the endocardium

are common factors. The authors believe this entity to be congenital rather than inflammatory and probably based on anoxia.

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OSTEOPETROSIS IN ADULTS*

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OSTEOPETROSIS (Albers-Schönberg's disease, marble bones, or osteosclerosis fragilis generalisata) is a rare disease characterized by early onset and by increased density of the skeleton. The disease is usually described in infancy and early childhood. In severe cases it probably begins in utero and progresses after birth. In this clinically "malignant" form there is usually marked anemia, hydrocephalus, blindness, cranial nerve involvement, low resistance to infection, and early death.

Some patients have a less fulminating form of the disease and they survive infancy only to succumb in childhood. These individuals often exhibit mental, dental, and sexual retardation, multiple fractures, dwarfism, and anemia.

A few patients appear to be clinically normal in childhood and adolescence, but the disease is discovered in adult life, usually by the radiologist. In contradistinction to the juvenile forms this condition has been little publicized and is very poorly understood since it is rare, and pathological material has been sparse indeed.

We have under our observation 5 adult siblings who have osteopetrosis. The disease was discovered roentgenologically at ages ranging from fifty-five to sixty-six years. The patients are still alive and we have secured bone for histological and chemical study from 2 of them. The roentgenograms of these interesting patients, together with their collateral studies, form the basis of this report.

HISTORICAL REVIEW

Albers-Schönberg[1] published the first case of osteopetrosis in 1904. The patient was a twenty-six year old man with severe anemia, multiple fractures, generalized bone sclerosis and hepatosplenomegaly. Eighteen years later, at the age of forty-four, he was still actively working. Thus, the original case was an adult with rather severe manifestations of the disease, but in whom there was a relatively benign course. When this patient came to autopsy, he had extramedullary hematopoiesis but unfortunately the bones were not studied.

Most reports of osteopetrosis deal primarily with the relatively well known infantile form. The first reports in the American literature were those of Davis[12] and Ghormley[17] in 1922. McCune and Bradley[39] published an excellent critical review in 1934, raising the total number of reported cases to 69. Subsequent reviews were published by Harnapp,[21] Nussey,[42], and Higinbotham and Alexander.[23] A total of 202 cases have been reported up to July, 1952. With the increasing use of diagnostic roentgenology, there has been an acceleration of case finding.

AGE, SEX, AND RACE

Although the majority of patients have been infants and children, 38 of the first 135 patients (28 per cent) were over twenty-one years of age when the disease was diagnosed. It is, of course, likely that there have been many undiagnosed fatal cases in infants. The "benign" form, on the other hand, may have been present early but remained undiagnosed until adult life when it was detected roentgenologically.

There is no predilection for either sex and the disease can be inherited from either parent.

The disease has been reported in many races. Cases have been reported in Negroes by several authors.[4,28,29,49]

FAMILIAL INCIDENCE

Review of the literature reveals that about 40 per cent of all cases of osteopetrosis and nearly 50 per cent of the adult cases

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are familial. In many of the early reports, siblings and parents were not studied, so familial cases are presumably more frequent than is appreciated. The disease is rarely seen in successive generations. Thomson[56] in 1949 found only nine families involved in this manner. All of these patients were classified as "benign" with the possible exception of a baby who was blind and mentally defective but not anemic. McPeak[40] in 1936 reported the only family to manifest the disease in three generations.

Usually only the siblings are involved, and in a large family there are commonly some normal siblings. Kelley and Lawlah[29] found the disease in only 4 of 10 siblings and the 4 were not consecutive. Analysis of the reported familial cases[20] reveals the ratio of involved to uninvolved siblings to be about 1:1.

The involved members of a family all tend to have the same manifestations of the disease and particularly tend to share any unusual features. The family reported by Higinbotham and Alexander[23] is one of the best examples of this. All showed syndactylism, which is assumed to be an incidental anomaly and they all had the same type of sclerosis in the mandibles, hands, ribs, and skull. The changes in the hands in Fairbank's adult female patient[13] are exactly duplicated in her daughter. Winter's 2 patients[61] showed familial involvement of the maxilla, and both had generalized homogeneous sclerosis like the Higinbotham and Alexander family. The family reported by McPeak and the siblings in our series are of a more characteristic type, showing symmetrical marked transverse and longitudinal striations in the bones.

Usually siblings have the same type of bone change, but there is often considerable variation in the severity of the disease. Nevertheless, we have been unable to find any report of childhood "malignant" and adult "benign" osteopetrosis in the same family. It appears that most of the severe fatal cases are isolated while the less severe or subclinical cases are in the siblings of one or more generations.

CONSANGUINITY AND HEREDITY IN OSTEOPETROSIS

Consanguinity, defined as marriage of cousins, occurs in about 0.5 to 1 per cent of marriages in the general population. Geneticists have long agreed that such marriages are unwise because of the probability of uniting undesirable recessive genes. As recorded in the literature, about 20 per cent of the cases of osteopetrosis occur in consanguineous marriages.[42] In these families there is frequent mention of stillbirths and mental defectives, providing ample evidence of the undesirability of such marriages. Moreover, the cases of osteopetrosis occurring in consanguineous marriages are apt to have a severe form of the disease. Nussey[42] states that the cases from consanguineous marriages are "malignant." While this is generally true, several authors have reported "benign" cases with consanguineous parents.[2,11,33,49]

In the majority of clinically "benign" cases there is no evidence of the disease in either the previous or subsequent generations. Hence it must be a recessive trait in most families. Children having the disease in a fulminating form do not reach maturity. The "malignant" form therefore cannot be inherited as a simple mendelian dominant trait.

It seems evident, then, that regardless of its clinical severity, the disease is usually genetically recessive. Human heredity is extremely complicated since it is known[18] that as many as 13 genes may determine a single trait. The dominance of any gene is relative depending upon the dominance of the gene with which it is paired. Probably the osteopetrotic gene is relatively low in dominance (recessive) but it may be dominant if paired with a gene still lower in the scale.

CHARACTERISTICS OF OSTEOPETROSIS IN ADULTS

In order to evaluate the usual picture of osteopetrosis in adults, we have reviewed

TABLE I*

ROENTGENOLOGICAL AND ASSOCIATED FINDINGS REPORTED IN 25 CASES OF OSTEOPETROSIS IN ADULTS

	Present	Absent	Unknown†
Roentgen Findings			
Involvement of pelvis	25	0	0
Long bones affected	22	0	3
Clubbing of clinoids	17	2	6
Hands affected	15	0	10
Pathological fractures	10	15	0
Facial bones affected	10	4	11
Coxa vara	5	19	1
Clubbed long bones	4	18	3
Open cranial sutures	2	21	3
Associated Findings			
Familial	13	6	6
Anemia‡	9	10	6
Defect of vision or hearing	5	1	19
Consanguinity of parents	3	12	10
Mentally dull	3	0	22
Palpable liver	3	14	8
Palpable spleen	2	15	8
Poor dentition	2	2	21

* Our patients are not included. The reports from which these cases were taken are listed in references 1, 2, 3, 5, 7, 8, 9, 13, 17, 23, 32, 33, 36, 40, 41, 47, 49, 56, 58, 61.

† Items were not mentioned or not studied.

‡ Only 3 had severe anemia.

the reported manifestations of the disease in patients over twenty-one years of age. Herscher and Stein's[22] patient was not included because it seems possible that the bone changes in his case may have been due to Hodgkin's disease. The frequency of some of the often mentioned features of osteopetrosis as reported in these cases is given in Table 1. Our own patients are not included.

Unlike the clinically "malignant" type of osteopetrosis, we see that severe anemia, clubbing of the long bones, and a palpable liver and spleen are rather uncommon in the adults. Only 28 per cent had any symptoms other than pathological fractures, and approximately 45 per cent of the group were completely asymptomatic. None had osteomyelitis, but 2 had delayed healing of fractures.

It is of interest that the pelvis was involved in every case. The sella turcica and base of the skull were considered normal in only 2 cases. In these 2 and in 1 other the calvarium was considered normal and in 1[49] it was thin, with parietal defects. The facial bones were more often spared than any others. In the 14 cases in which the maxilla and mandible were mentioned, they were each involved 8 times, either separately or concomitantly.

Delayed closure of the epiphyses was mentioned only once, but delayed closure of the cranial sutures was present in 2 cases. One of these[49] also had defective terminal phalanges. These associated anomalies suggest a relationship to cleidocranial dysostosis, but the clavicles were normal. The anomalous phalanges are interesting in the light of the two cases recently described by Thomsen and Guttadauro[55] showing typical cleidocranial dysostosis associated with osteosclerosis and bone fragility. The published roentgenograms of these cases, however, do not show the typical changes of osteopetrosis and we did not include them in Table 1.

ROENTGENOLOGICAL CHANGES OF OSTEOPETROSIS IN ADULTS

The basic roentgenographic change in osteopetrosis is a bilateral symmetrical increase in the density of the bones, with loss of the normal trabecular pattern. The "typical" roentgen change in osteopetrosis, as described in most textbooks, is the roentgen picture seen in the "malignant" form in childhood, but this pattern is not limited to the very young, and may be seen at any age. From a strictly roentgenological standpoint there is no clear distinction between the clinically "benign" and "malignant" types. All patients who survive infancy presumably have a relatively benign form of the disease.

Probably the roentgenological findings in adults represent the culmination of growth and replacement abnormalities which have been present for a number of years.

The disease probably begins in childhood

but the rapidity of progression is quite variable. Some patients have prolonged remission in childhood and even show definite improvement.[40] Phases of actual demineralization have been reported.[13] Despite variability in the severity and some differences in distribution, review of the literature discloses that the roentgen changes reported in adults can be summarized as follows: (Selected roentgenograms of the 5 siblings in our series will serve to illustrate some of the classical manifestations.)

Long Bones. In the mildest cases, there may be only dense transverse bands in the metaphyses. These are usually seen at the proximal end of the humerus and both ends of the femur. The distal end of the humerus, the proximal ends of the radius and ulna, and the phalanges are the bones most likely to be normal in a case of moderate severity. The dense bone blends into normal bone.

Fig. 1. Illustrative film from Case II. Right knee, male, aged sixty. The distal femur (outline emphasized) is increased in density especially in the metaphyseal and old epiphyseal areas. In the tibia the sclerosis is below the tibial spines and also distal to the previous epiphyseal line. The vertical striations are well demonstrated in the tibia.

Fig. 2. Overpenetrated film. Right knee from Case IV. Male, aged sixty-four. There is very marked involvement and some clubbing of the long bones, not only at the ends but throughout the shafts. Apparently this patient developed the disease very early, and it continued through the growth period.

In the most severe cases the entire shaft may appear to be uniformly dense. On heavily penetrated roentgenograms one can see thickening of the cortex. Transverse bands of alternating density are usually visible in the metaphyses and vertical striations are common near the ends of the long bones. Mild and severe changes can be seen in Figures 1 and 2.

The sites of previous epiphyses often contain a central dense nidus and may show several concentric layers of varying density, producing a "bone within a bone" appearance. Not infrequently the most recent bone laid down is of normal density. Clubbing of the metaphyses occurs only in the moderately advanced cases. It is most likely to be seen in the distal ends of the femur and the proximal end of the humerus. The articular cartilage is unaffected and the joint spaces are normal, except in elderly patients who develop de-

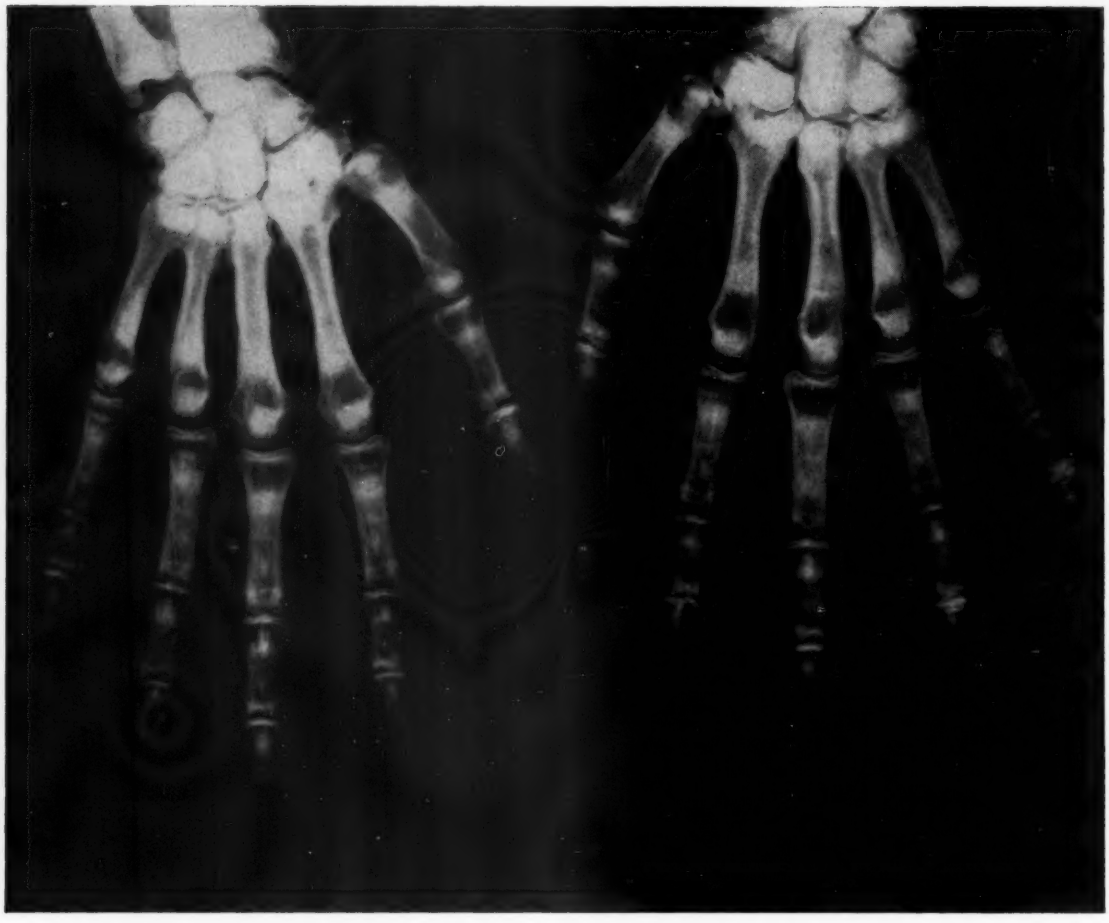

Fig. 3. Hands from Case 11. Male, aged sixty. The metacarpal shafts and middle thirds of the phalanges are dense. The ends of the bones which were once metaphyses are normal in density. Sclerotic nidi are seen in the phalanges and in both ends of the metacarpals. The symmetry in the two hands is characteristic of this disease. The carpals are seen to better advantage in Figure 19.

generative changes.

Carpals and Tarsals. In these small bones the changes are interesting and characteristic. The mildest change consists of a dense central nidus resembling a bone island. If the nidus is larger it usually has the general shape of the bone within which it lies. The peripheral bone is usually of normal density. It is here that the "bone within a bone" appearance is best seen, especially in the astragalus, os calcis, and tarsal navicular. This is exemplified in Figures 18 and 19.

Hands. The bones of the hands often appear normal. If they are involved, however, the roentgenological appearance is characteristic. The mildest changes consist of dense medullary islands in the proximal ends of the phalanges and in both ends of the metacarpals. The dense areas are not restricted to the epiphyseal ends of the bones. At this stage, illustrated in Figure 3, the dense islands resemble osteopoikilosis. In severe cases there may be diffuse increase in density of the metacarpals and phalanges with widening of the shafts.[23] In all except very severe cases the cortices appear normal.

Pelvis. The pelvis is commonly involved. It may be diffusely dense or it may be dense only in the central portions of the pubic and ischial bones, with rings of alternating

increased and diminished density extending out to the margins of the iliac bones in a striking concentric manner. The appearance of these concentric rings (Fig. 4) suggests the growth rings in the cross section of a tree trunk. The concentric rings are similar to those seen in growing children who have ingested heavy metals. In addition, in some cases there are dense lines fanning out radially from what were presumably the original ossification centers. These resemble the changes in osteopathia striata.[24]

Spine. The changes in the spine may consist of only thin dense plates at the upper and lower borders of the vertebral bodies. Commonly, in spite of the dense plates, the middle thirds may be normal in density, producing a "sandwich" appearance, especially in the lateral view. The phenomenon is well shown in Figure 5. The posterior elements and transverse processes of the vertebrae generally show changes of considerably lesser degree.

Ribs. The mildest change may be a diffuse ground-glass appearance, which is not a specifically diagnostic finding. Typically, however, one finds rectangular islands of sclerosis of varying lengths within the ribs. Each rib may contain a complete, dense, smaller edition of itself. In advanced cases, the ribs may be uniformly dense and may become twice normal width.[23,28]

Fig. 4. Pelvis from Case II. Male, aged sixty. This illustrates severe intermittent involvement. The concentric bands are prominent in the ilia. The central portions of the iliac bones are normal in density. The coxa vara deformities probably indicate old femoral neck fractures. The lumbar spine, sacrum, pubis, and femora are also increased in density.

Fig. 5. Lateral lumbar spine from Case I. Male aged fifty-eight. This is an excellent example of "sandwich vertebrae." There is marked contrast between the abnormally dense superior and inferior surfaces and the centrum which is normal in density. The posterior elements are only mildly sclerotic.

Shoulder Girdle. The clavicle usually displays spotty involvement. The increase in density of the scapula is most marked around the glenoid, neck, and coracoid (Fig. 6). The humerus, which is often

FIG. 6. Right shoulder from Case II. Male, aged sixty. Overpenetrated film. There is no medullary cavity. The humerus is dense, bowed, and clubbed. The scapula, clavicle, and ribs are extensively involved.

clubbed and is usually involved in a characteristic manner, was discussed under long bones.

Skull. Skull changes are variable. They are slight in our series. The most characteristic changes are in the sella turcica. These consist of thickening of the posterior and to a lesser extent of the anterior clinoids (Fig. 7). In more severe cases there is thickening of the floor of the sella turcica and encroachment upon the sphenoid sinus. Often the entire base of the skull is sclerotic and thickened, with obliteration of the mastoid cells, and the sphenoid, frontal, and ethmoid sinuses. In addition there is often narrowing of the foramina of the base of the skull, and of the optic foramina. Less often, there is diffuse homogeneous thickening of the vault with obliteration of the diploe. The thickening of the vault may be tremendous, leading to over-all enlargement of the head.[23,28] Even when this occurs, however, the resemblance to Paget's disease is only superficial.

Facial Bones. As elsewhere, the involvement is always bilaterally symmetrical and may vary from a normal appearance to complete sclerosis of the orbit, maxilla, and mandible. In advanced cases there is usually obliteration of the maxillary sinuses. In one family[23] all members showed prognathism with sclerotic mandibles, but in most reported cases the mandibles have been normal or hypoplastic.[49]

DIFFERENTIAL DIAGNOSIS

No other disease presents the typical roentgenological appearance of osteopetrosis in adults. The diagnosis can be made in most cases on the basis of the following roentgenological and clinical characteristics:

1. The disease is generalized, although some bones may be spared.
2. There is usually involvement of the posterior clinoids, spine, pelvis, proximal humeri and both ends of the femurs.
3. There is pronounced symmetry of the lesions.
4. The "bone within a bone" appearance is often seen in the pelvis, ribs, epiphyses, carpals, and tarsals.
5. There are usually transverse and longitudinal striations in the metaphyses.
6. The vertebrae may present a "sandwich" appearance.
7. The disease probably begins in early childhood.

FIG. 7. Lateral skull from Case II. This illustrates the usual sites of skull involvement although this is less striking in our patients than in some others previously reported. The posterior clinoids, dorsum sellae and floor of the middle fossae are increased in density. The skull appeared otherwise normal.

8. It may be found in other members of the family, especially in siblings.
9. Anemia is moderate or absent; seldom severe.
10. The serum alkaline and acid phosphatase, blood calcium, and phosphorus are essentially normal.
11. Enlargement of the liver and the spleen is uncommon.
12. There is a predilection to fracture.
13. There may be periodic or permanent remissions.
14. The course is clinically benign.

The following conditions may also be associated with increased density of bone and may simulate osteopetrosis to a variable degree. Each of these have well recognized differential characteristics which permit their identification. Some of the useful points of contrast are mentioned below.

(a) *Myelosclerosis.* Progressive severe anemia and splenomegaly; patchy or diffuse, but never transverse, parallel lines in the bones; no predilection to fracture; not familial; begins in adult life; downhill clinical course.

(b) *Fluorosis.* All growth centers involved; calcification of ligamentous and tendinous structures; high fluorine in water supply; no tendency to fracture; skull not affected; mottled teeth; no clubbing of clinoids or long bones; chemical and histological study of bones is diagnostic.

(c) *Lymphoblastoma* (especially Hodgkin's disease and leukemia). Skull, tarsal and carpal bones rarely involved; splenomegaly, lymphadenopathy and anemia; no parallel transverse striations in bones; rarely generalized or symmetrical bone involvement; downhill course.

(d) *Metastatic Osteoblastic Carcinoma.* Very rarely generalized or symmetrical;[52] never parallel, transverse, or vertical striations; elevated acid and/or alkaline phosphatase; downhill course.

(e) *Paget's Disease.* Very rarely generalized and symmetrical;[25] coarsening of trabeculae; bowing of long bones; alkaline phosphatase usually elevated; onset almost always late in life.

(f) *Lead, Bismuth, and Phosphorus Poisoning.* Astragalus and sphenoid spared; dense lines appear only during growth period and then gradually fade. Do not persist in adult life.

(g) *Infectious Osteitis.*[16] Few typical marble bone features; signs of infection; diagnosis made by bone biopsy.

(h) *Osteopathia Striatum* (Voorhoeve's disease). Striped bones. The classification of this disease is uncertain; it may be an unusual variety of osteopoikilosis. A recently reported case[24] had some resemblance to osteopetrosis.

(i) *Engelmann's Disease.*[35] Endosteal and periosteal new bone, with thickening of diaphyses; metaphyses and epiphyses spared; weakness, weight loss, and muscle wasting.

PATHOLOGY

Published descriptions of the pathology of osteopetrosis are based almost entirely upon the infants and children dying of the disease. The scanty information, which is available in connection with the disease in adults, has been obtained from biopsy material. Certain of the gross and microscopic characteristics are common to the disease both before and after puberty. As a rule, one finds less long bone clubbing, less medullary involvement, less foraminal encroachment, and less universal involvement in adults than in infants. Other typically adult features are discussed and illustrated below.

Gross and Chemical Characteristics of "Marble Bones." The bones are heavy, thick, dense, hard, and brittle. The "chalky," rather soft, character of the bones in Pirie's case[47] has not been described by other writers and is not present in our cases. The term "marble" seems to us to be apt. Clifton[10] states that the bone seems to have no cleavage planes, "fragmenting in the irregular fashion of glass."

The medullary cavity is reduced in size or is practically absent. As one would expect, ash studies have shown a relative increase in the inorganic components of "marble bones."

The bone ash of normal human bone varies from 55 to 67 per cent depending upon the age of the patient, according to Kramer.[31] He and Pincus[45] have studied osteopetrotic bone showing ash values as high as 67 to 72 per cent of the dried fat-free bone. This is definitely more ash than is found in the bones of normal children of the same age, but is about the same as is present in fetal bone at sixteen to eighteen weeks. There is also some increase in the ratio of carbonate to phosphate in the osteopetrotic bone of children, but the ratio does not exceed the normal adult value. The calcium/magnesium ratios are normal, and no abnormal chemical elements have been reported.

Histopathology. Microscopically, osteopetrosis at all ages is characterized by persistence of excess dense bone and matrix which, for some reason, is not resorbed in a physiological manner. Probably the bone is abnormally resistant to the forces of resorption. Zawisch-Ossenitz[62] belives that it is undifferentiated or primitive as the result of damage to the bone-forming blastema in utero. Very little is known of the histopathological characteristics of osteopetrosis in adults, since scanty material has been available for study. Most of the reports are based upon biopsy material as is the case in our presentation. The histological descriptions in the literature vary tremendously depending upon such factors as the age of the patient, the bone selected for sectioning, and the relation to the epiphyseal line.

At all ages, however, one finds histological evidence of excess bone and calcified matrix in trabeculae and cortices. Dense cement lines, faulty cartilage and bone resorption, scanty marrow elements, excess osteoid tissue, excess calcified matrix, and abnormal persisting chondroid tissue are typical of the disease. These constitute the essential characteristics upon which the histopathological diagnosis rests.

Cartilage cells have been described in the bones of adults having osteopetrosis. This is interesting since normally all cartilage should have been destroyed during the phase of growth. Laubmann[34] described them in the metaphyses of a twenty-five year old male. Callender[7] showed them in the resected femoral neck of a twenty-four year old male and they have been commented upon by others. Presumably the cartilage persists because of deficient resorption.

Dense blue-staining cement lines between layers of bone and surrounding cartilaginous rests or matrix often form a mosaic. These lines are believed to be very resistant to resorption. In older patients, the relative increase in lamellar bone, thickening of the cortex, and modifications in the haversian systems are believed[62] to represent differentiation and repair. Study of sectioned bones with polarized light reveals a scarcity of fibrils (a factor in their fragility). Most of the modern observers believe that osteoblasts and osteoclasts are present in normal numbers although the former may be flattened and not readily recognized.

Excessive bone accumulates because of disharmony between deposition and resorption.[60] It has not been determined whether the bone laid down is abnormally resistant to resorption or whether the vascular and chemical forces of resorption are deficient. It is probable that each affects the other adversely. For example, if the bone is resistant, the invading vessels cannot penetrate, cement lines grow thicker, and the increased bone mass becomes progressively more under-vascularized. In very sclerotic areas the bone cells (osteocytes) disappear as the result of avascularity and the bone undergoes necrosis.[60]

Theories of Pathogenesis. It is probable that the disease results from a genetic mutation, but the actual mechanism by which the genetic defect produces the observable changes is unknown. Many theories of pathogenesis have been advanced and the most widely accepted theories are briefly reviewed below. This summary is based upon the medical liter-

ature which includes the severe infantile type.

1. *Primary disease of the osseous system.* Abnormal matrix is laid down which is resistant to normal resorption.

2. *Primary inflammatory disease.* Osteosclerotic changes, somewhat similar to those of osteopetrosis, have been observed in infectious diseases in animals. A virus disease, known as "osteopetrosis gallinarum," has been described in birds.[6,54] In certain reported biopsy specimens,[16,30] inflammatory cells were seen.

3. *Primary endocrine disturbance.* Pincus[45] believes that there may be some degree of hyperparathyroidism. Selye[50] has produced sclerotic changes in the bones of experimental animals by injecting parathyroid hormone. Several other workers[43,44,51,52] found that estrogenic compounds administered to animals cause sclerosis of the metaphyseal portions of the long bones which simulate the changes of osteopetrosis.

4. "*Faulty differentiation of the primitive common forerunner of osteogenic and hematogenic tissue.*" This is probably the most widely accepted theory at present.

Anemia. Severe anemia characterizes the "malignant" infantile form of osteopetrosis. In adult patients there is usually little or no anemia and the medullary cavities are at least partially preserved. Peculiarly enough, the anemia even in infancy and childhood is not always directly proportional to the severity of the bone changes. For this reason, it is improbable that the latter is the direct and only cause of the former.

It appears that there may be three principal causes for the anemia. These probably complement each other.

1. Deficiency of the undifferentiated mesenchymal cell (the common ancestor of bone and blood forming tissues).

2. Absence of hematopoietic stimulation which normally results from bone resorption.[48]

3. Physical crowding within the narrowed medullary cavities.

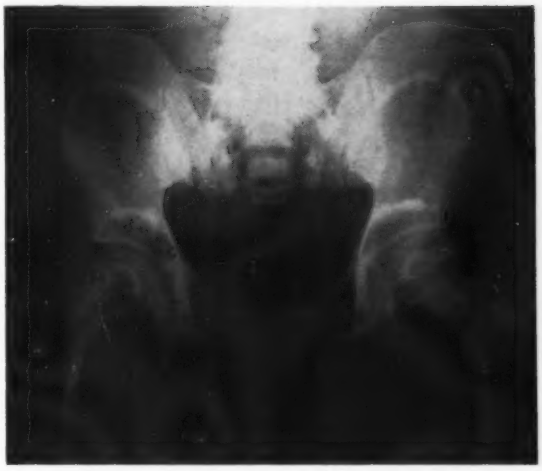

FIG. 8. Case 1. Pelvis, male, aged fifty-eight. Sclerotic outlines of childhood iliac bones are clearly seen. Dense rings are visible in the femoral heads and areas of increased density are found in the sacrum, femoral necks and trochanters, pubic bones, ischii and lumbar spine. This is minimal involvement.

CASE REPORTS

CASE 1. Mr. E. J. D., a fifty-eight year old garage owner, was admitted to this hospital on July 8, 1950, complaining of severe low back pain which radiated around the buttocks bilaterally. The pain developed shortly after a fall on the ice. His past medical history was negative except for the usual childhood diseases. His family history was negative except that his mother "always had a limp."

On physical examination the patient was a well developed man, not unusual in appearance. Weight 190 pounds. Blood pressure 164/100. There was considerable limitation of motion in the lumbosacral region presumably secondary to splinting. No other abnormalities were found on physical examination.

Anteroposterior and lateral films of the lumbosacral spine and skeletal survey films were secured. A few of his roentgenograms are reproduced in Figures 5, 8, and 9.

After these striking bone changes were seen, the patient was more carefully questioned. There was no history of exposure to heavy metals or fluorine. He was robust and healthy throughout his childhood and his only fracture followed adequate trauma. He had no previous roentgenological examinations. He is married and has three healthy children. One brother died of pneumonia and hypertensive cardiovascular disease at the age of fifty-five. He never

FIG. 9. Case 1. Right elbow. Male, aged fifty-eight. There is central sclerosis of the previous secondary centers of ossification in the distal humerus (black arrows). The ulna is normal. The radial neck is involved between the white arrows. For some reason, 3 of our patients have involvement of the radius in this area.

had a roentgenological examination and was not known to have any bone or joint disease. Four brothers and a sister are apparently well. The patient believes that his deceased parents were not related.

Laboratory Data. Urine—negative; hemoglobin—13.5 grams; red blood cell count—4.5 million; white blood cell count—4,750; normal differential; serum alkaline phosphatase—5.1 (K-A units); serum acid phosphatase—2.7 (K-A units); blood Kolmer and Kahn reactions—negative; erythrocyte sedimentation rate normal; spinal fluid normal.

A lumbar myelogram was done on July 19, 1950. The subarachnoid space was found to be narrowed and tapered, especially on the left side at the levels of L-5 and S-1. The filling defect suggested encroachment upon the neural canal by bone or by extradural tumor.

On July 21, 1950, a laminectomy was performed at L-5 and S-1. The bone was extremely hard. There was marked thickening of the dura. Old hemorrhage and narrowing of the bony canal were found. The laminectomized bone was retained for study and the body of L-5 was biopsied. The fifth lumbar disc appeared to be normal and was not removed.

Following operation the pain was relieved and he was able to walk unaided. He has been followed for three years and remains symptom free. Presumably his symptoms were produced by hemorrhage secondary to the fall on the ice.

The resected bone fragments were sent to our pathology laboratory, and to the Pathology Laboratory of the Johns Hopkins Hospital where they were studied by Dr. Richard Follis.

FIG. 10. Case 11. Lumbar spine, lateral view. Male, aged sixty. The involvement is more extensive than that in his brother shown in Figure 5. The vertebral bodies and the posterior elements are increased in density.

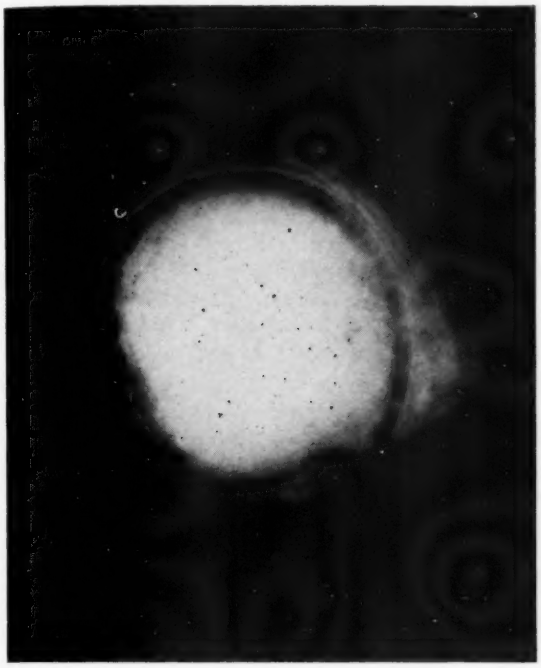

Fig. 11. Case II. Roentgenogram of removed femoral head before sectioning. The central bone is about three times normal density. The peripheral layers appear to be normal in density and contain trabeculae of normal pattern. The excrescence at the right represents overproduction of bone, a secondary change.

Fig. 12. Case II. Photomicrograph. Femoral head. Magnification 100×. Nests of unresorbed cartilage cells are embedded in dense bone of abnormal pattern. Osteocytes are scarce. Cement lines are dense. This bone may no longer be viable. The appearance is typical of osteopetrosis.

Both pathologists made a histopathological diagnosis of osteopetrosis. An excerpt from Dr. Follis's report[15] follows: "The fragments show a peculiar pattern with a cartilaginous calcified matrix imposed in bony trabeculae which are lined also by a small shelf of osteoid. *Diagnosis:* Lumbar vertebra: marble bone."

A fragment of cancellous bone was sent to the National Institute of Dental Research, Bethesda, Maryland where it was analyzed[38] for fluorine and bone ash content. The ash and fluorine values were found to be normal.

Case II. C. G. D., male, aged sixty, is a mechanic who had pain in both hips and was glad to be studied. Roentgenograms of his pelvis, spine, long bones, hands, etc., are shown in Figures 1, 3, 4, 6, 7, and 10. This man, like his brother, had no symptoms during childhood or early adult life. At the age of fifty-five, he developed arthritic symptoms and was studied at another hospital,* at which time the changes indicative of osteopetrosis were found.

The symptoms of pain and limitation of motion in the hips were so disabling that he was admitted to this hospital for an arthroplasty of the left hip. At the time of admission, March 16, 1953, laboratory data were as follows: Urine—negative; hemoglobin—14.5 grams; white blood cell count—4,900; serum alkaline phosphatase—3.5 (K-A units); serum calcium —5.4 mEq./L.; serum phosphorus—3.4 mg/ 100 cc.

On March 17, 1953, an arthroplasty replacement of the left hip was done. The bone was extremely hard and a Gigli saw was broken in cutting though the femoral neck. The neck was drilled with difficulty and a vitallium stainless steel replacement was fitted into the acetabulum.

The removed femoral head was extremely heavy. A roentgenogram of it is shown in Figure 11. It was frozen and cut into serial

* Dr. William Jones of Pottsville, Pennsylvania, was kind enough to send us the films made five years ago.

FIG. 13. Case III. Left tibia and knee. Male, aged fifty-five. Marble bone is seen in the femoral condyles, beneath the tibial spines and in the proximal tibia which was once the metaphysis. There is a broad band of normal appearing bone in the next few centimeters which terminates in transverse stripes of abnormal density. The fibula is practically spared.

sections. After fixation the bone sections were sent to our pathological laboratory, to Dr. H. L. Jaffe, and to Dr. R. H. Follis.

All pathologists agreed upon the histological diagnosis of osteopetrosis. Dr. Jaffe[26] commented upon the excess of calcified cartilaginous matrix and on the acellularity of the dense osseous tissue which he thought might be undergoing disintegration. The lack of bone cells and the islands of persisting cartilage cells are well shown in Figure 12. It is unlikely that this bone is viable.

One section of the removed femoral head was dried and was rendered fat-free by alcohol and ether extraction after which the ash content was determined.* The results follow:

Fat content of dried bone	7.8%
Ash content of dry, fat-free bone	65.9%

Another piece was analyzed. The results follow:

Calcium content of dried whole bone	29.2%
Phosphorus content of dried whole bone	10.8%

CASE III. W. N. D., male, aged fifty-five, is a symptom-free contractor who appears to be in excellent health. His blood count is normal. No additional laboratory studies were performed. Roentgen studies showed changes in general similar to those seen in Case I. Some of his films are shown in Figures 13, 14, and 15.

CASE IV. W. L. D., male, aged sixty-four, has retired after an active and successful business career, and is enjoying excellent health. His blood count is normal. This patient has the most extensive long bone changes of the siblings (Fig. 2). Although his pelvis is composed entirely of abnormal bone (Fig. 16), his hips have not fractured and have not undergone degenerative changes.

CASE V. E. C. D., female, aged fifty, sustained a tibial fracture in a fall. Her extremity films, made elsewhere,† disclose definite osteopetrosis in the femur, tibia, fibula, and patella. The changes, which are moderate in degree, are identical in character with those found in her brothers. We have been unable to obtain additional films of this patient.

Family Survey. Following the discovery of the osseous changes in our Case I, we examined his 4 living brothers and a sister. One brother, sixty-six years of age, had apparently normal bones. His 3 other brothers and his sister were found to have abnormal bones, and have been described above. We have also examined all (12) of the offspring (ages 19 to 35) of the involved patients and have found no evidence of the disease. We have obtained films of the pelves of all (15) of the grandchildren (ages 9 months to 6 years) and have seen no abnormalities. It will be of interest to observe them throughout the growth period.

EVALUATION AND COMPARISON OF THE PATIENTS IN THIS SERIES

Study of the shaded skeletons representing our patients (Fig. 17) provides some interesting information.

1. The familial osseous traits are similar in over-all pattern although they differ in severity.

* The fat and ash determinations were carried out by Mr. James C. Rohland, Chemical Control Division, Cherokee Plant, Merck and Company, Inc.

† Dr. Joseph Carr of Peckville, Pennsylvania, was kind enough to lend us the films of the fractured lower extremity.

2. There is some variation in the site of maximum involvement among the siblings.

3. Some bones were completely spared.

4. Although the disease characteristically affects the ends of long bones and areas which were once growing metaphyses and epiphyses, not all growth areas are involved.

5. Frequently only one end of a long bone is involved while the other end appears to be normal, even though the bone may originally have grown from both ends.

6. There is perfect bilateral symmetry in each patient.

7. Islands of discrete density are found in some areas which were once epiphyses or metaphyses (femur, proximal tibia, distal radius).

8. In some bones, dense zones occupy areas which never had epiphyses (proximal metacarpals, distal clavicles).

9. Bones which originated from single centers of ossification and grew by apposition tend to show the "bone within a bone" appearance (tarsals, carpals).

10. The degree of bone change does not correlate with the ages of the siblings.

Fig. 14. Case III. Left shoulder. A small dense (juvenile) humeral head is surrounded by more recent bone of normal density. Longitudinal dense streaks persist in the metaphysis. The glenoid, axillary border and coracoid process of the scapula are diffusely dense. Discrete islands are indicated (arrows) in the distal clavicle and anterior ribs.

Fig. 15. Case III. Detail view lateral thoracic spine. Here the dense superior and inferior vertebral plates appear to be in three layers suggesting exacerbations and remissions during growth. The ribs, lumbar spine, and pelvis were also involved but are not reproduced.

11. In some areas the last formed bone is of normal density (pelvis, vertebrae, small bones).

The sites of osteopetrotic changes are indicated in Table II which also provides an approximate quantitative comparison. Unfortunately, we could not complete the skeletal survey in Case V.

DISCUSSION OF TIME OF ONSET AND COURSE OF THE DISEASE

It appears from the literature that there may be considerable variability in the time of development of osteopetrosis not only in different patients but also in different bones of the same patient. Several authors have

Table II

	Case I	Case II	Case III	Case IV	Case V (Incomplete)
Spine	++	++++	++	++++	−
Pelvis	+	+++	++	++++	−
Ribs	++	+++	+	+++	−
Scapula	+	++	+	++	−
Ends of long bones	+	+++	+	++++	++
Diaphysis of long bones	o	+	+	+++	+
Floor of skull	+	++	o	++	−
Wrists and ankles	o	++	o	++	−
Phalanges	+	++	o	+	−
Clavicle and radial neck	o	++	+	++	−

attempted to establish a definite time of onset.

Zawisch-Ossenitz[62] studied fetal and growing bones extensively and has recently interpreted the osseous changes in Windholz's case of osteopetrosis. The child died at the age of thirteen months. She presents convincing evidence that (at least in Windholz's case) osteopetrosis developed between the fourth and fifth months in utero. Other authors[40,60] state that the disease may begin at any time before closure of the epiphyses.

Kneal and Sante[30] reported a patient who, at the age of three and a half months, had slightly dense metaphyses and a large head. During ten years of observation, the disease developed into typical osteopetrosis of the entire skeleton.

Fig. 16. Case IV. Pelvis. Male, aged sixty-four. This patient's pelvis is different from the others in that there is no bone of normal density. Even the primary ossification centers were involved, indicating that this patient developed the disease earlier than his brothers or his sister. The curved lines below the crests probably indicate remissions. The hip joints are remarkably normal for a patient with such severe bone changes throughout the skeleton.

Pirie[47] reported dense zones in certain metaphyses of 3 children, five, eight, and eleven years of age. He attributed this to early osteopetrosis, but was able to follow the patients only two years, at which time the sclerosis had progressed slightly.

McPeak[40] reported early roentgenological changes characteristic of osteopetrosis. He obtained roentgenograms of several children in one family when their changes were minimal and observed the progression for five years. In one child there were only dense zones at the metaphyses when first seen at the age of eleven months, but ten months later the child had developed sclerotic zones at the superior and inferior surfaces of the vertebrae. Roentgen studies revealed that the disease was first evident in the humerus, femur, tibia, and pelvis, and later developed in other long bones, the vertebrae, and the skull.

The reported cases indicate that osteopetrosis usually begins very early in life, but does not affect all bones equally or simultaneously except in the fulminating, clinically "malignant" cases. To our knowledge, no one has ever described a normal skeleton in a patient who later developed this disease.

When, as in the family reported here, the first roentgen examination is in adult life, one has only two criteria which permit an

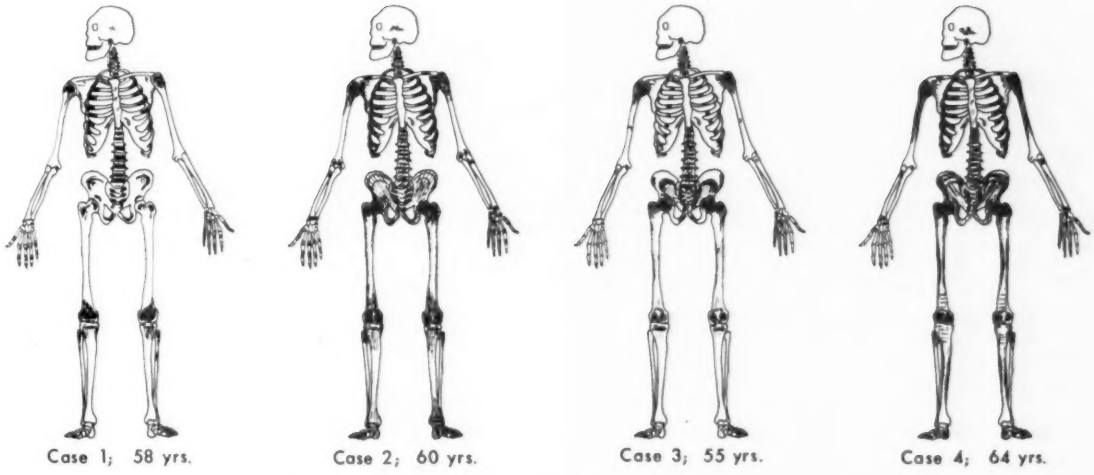

Fig. 17. Shaded skeletons indicating bone involvement. The familial distributional pattern is striking. The sites of involvement are indicated. It is of interest to note the less prominent lesions in the ribs, hands, feet, dorsum sellae, radial necks and clavicles. The changes indicated here are correlated in Table II. The oldest sibling (male, aged 66) had normal bones. Case V would not submit to a complete skeletal survey and is not included.

estimate of the time of onset. One is a history of pathological fractures in childhood. The other is the size of the inclusions of normal density within the osteopetrotic areas (a method not previously described). These inclusions are best seen in the areas where the "bone within a bone" appearance is prominent, for example in the tarsals, carpals, and previous epiphyses. We suggest that it is justifiable to regard these central areas (of normal density) as the normal juvenile bone which formed before the onset of osteopetrosis. On this basis one can determine approximately the age at which the bone or epiphysis became osteopetrotic.

The os calcis of Case II (Fig. 18) may severe as a specific example. The inclusion (of normal density) measures 34 mm. in transverse diameter and it has the size and shape of an os calcis at three years of age. The normal bone at the periphery presumably indicates a long remission of the disease before the end of the growth period. Hence the disease in this particular bone probably was active from about age three to early adolescence.

Likewise the wrist bones of the same patient in Figure 19 contain central areas of normal density which correspond in size to the ossification centers at about nine months of age. The scaphoid (which is uninvolved) usually appears at about six years of age in males.[19]

Certain large epiphyseal inclusions are readily measurable and may be utilized in a similar manner. The size of the distal femoral epiphyseal inclusion in Figure 1 sug-

Fig. 18. Lateral foot from Case II, male, aged sixty. The osteopetrotic changes are moderate in the distal tibia and fibula. They are marked in the tarsal bones and in the metatarsals. The inclusion of normal density within the os calcis (between arrows) indicates that the infantile os calcis was probably normal until about age three years.

FIG. 19. Right wrist from Case II. The "bone within a bone" appearance is well exemplified in the distal radius, capitate and proximal metacarpals. In the central portion of the inclusions the bone is normal in density. Probably the inner inclusion (slightly retouched) represents bone which was formed before osteopetrosis developed. The size of the inner inclusion in these bones indicates an onset at about nine months of age.

gests an onset of osteopetrosis in this bone at about age four. That of the proximal humerus in Figure 14 suggests an onset at about three and a half years. The infantile pelvic inclusions seen in Figures 4 and 8 correspond in size with normal pelves of four and a half and six years of age. In contrast, the entire pelvis of Case IV (Fig. 16) is involved, suggesting a prenatal onset.

Some of the involved long bones have segments of normal density in their diaphyses which were presumably formed before the disease developed. The uninvolved diaphyseal segments in Cases I, II and III, when measured and compared with normal standards,[59] correspond with normal bone lengths at two and a half to five years of age. As mentioned above, Case IV is an exception to this, since his mid-diaphyses also are involved, indicating a probable prenatal onset.

We are led to conclude that the disease developed in the various bones of our siblings at different ages but always in early childhood or before. Certain bones, especially the proximal humerus and the femur, were involved earlier than others. Probably the disease existed in the pelvis and long bones of Case IV in utero while in the others it began in the first two years of life. The present adult size, appearance, and structure indicate that each has passed through several cycles of exacerbation and remission. The normal density of the peripheral bone suggests that, when it was laid down, the disease was no longer active.

SUMMARY AND CONCLUSIONS

1. We have reviewed the clinical and roentgenological findings of osteopetrosis in adults and have presented one female and four male siblings showing bone changes characteristic of the disease. In adults the manifestations are different from those of the better known infantile form. The course is clinically benign and hematological and neurological findings are minimal or absent. Long bone clubbing, medullary narrowing, and foramen encroachment are not prominent. The disease may be asymptomatic.

2. The disease probably develops as the result of an hereditary trait which is governed by one or more genes of intermediate dominance. The essential defect appears to be inherent in the mesenchyme which is the common ancestor of hematogenic and osteogenic cells. In siblings, the type and distribution of the bone changes are highly characteristic of the family. There may be, however, considerable variation in the time of onset and in the severity of the disease. We have not found it in the children or grandchildren of our patients.

3. The increase in density results from faulty resorption of endosteal and periosteal bone and matrix. Cartilage cells and unresorbed matrix are found in the bones

of adults as late as the seventh decade. Osteopetrotic bones are increased in weight, fragility, and mineral ash content. In patients of this age the dense inclusions are probably not viable.

4. The roentgenological findings are sufficiently characteristic to justify a diagnosis. The disease may involve endochondral or membranous bone and may include primary and secondary ossification centers. The distribution in our patients is widespread but some bones are completely spared while others are only partially affected. Measurement of the central nidi (of normal density) in the osteopetrotic inclusions permits estimation of the time of onset in certain bones. On this basis we suggest that the onset time in some bones of our five patients ranged from the prenatal period to about four years of age.

It is our impression that although several exacerbations and remissions have occurred, the osteopetrotic inclusions have been enveloped by normal bone and that the disease is no longer active.

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OSTEOID OSTEOMA OF THE FEMORAL NECK*

REPORT OF THREE CASES

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IN AN eight month period 3 cases of osteoid osteoma were observed and subsequently removed with complete relief of symptoms. These cases are of particular interest not only because of their histopathologic diagnosis, but also because of their location and the effect of this location upon the clinical problem. Each of the cases was on the anterior margin of the femoral neck and 2 were intracapsular.

Since the original description of the tumor in 1935 by Jaffe,[2,3,4] over 160 cases of the entity have been reported in the literature. Of these only 8 cases[1,4,5,8,9] were specifically described as located in the femoral neck. Others may have been in the neck but were included with the femur cases. Nearly all of the large series of cases reported have found the largest number of cases in the femur and tibia.[1,9]

Little attention has been called in the radiological literature to the significance of the lesion being located near a joint or intracapsular. Sherman[8] described a case in which the osteoid osteoma was a double lesion involving the femoral neck, with associated changes in the hip joint resulting in degenerative hip joint changes.

All 3 of the cases forming the basis of this report had hip joint complaints or findings.

FIG. 1. Case 1. Lateral view of right hip showing a rounded subperiosteal bony tumor. Margin slightly retouched.

REPORT OF CASES

CASE 1. R.D., a twenty-two year old white male admitted on October 24, 1952, with a chief complaint of pain in the right hip of ten months' duration. This was a constant type of localized hip pain. He had been walking with a limp. On physical examination the patient was well developed, well nourished, and appeared in good general health. The temperature was 36.7° C. The right hip had limitation of flexion, external and internal rotation. There was point tenderness over the anterior right hip joint and a minimal amount of muscle atrophy. Laboratory findings. Urine was normal. Red blood cell count was 5.06 million. Hemoglobin was 16.5 gm. per 100 ml. White blood cell count was not done. Kline test negative. Films of the right hip were interpreted as follows: "There is a bony tumor arising from the cortex of the anterior portion of the base of the neck, just lateral to the intertrochanteric line (Fig. 1). The base of the lesion is 3.0 cm. The main portion shows a trabecular type of bone with a small zone of radiolucency. Objectively its appearance is that of an osteochondroma. Because of its rapid development osteochondrosarcoma must be kept in mind. Other possibilities include osteoid osteoma."

The preoperative diagnosis was bone tumor.

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† Resident, Department of Radiology.

Fig. 2. Case 1. Gross specimen with the 1 cm. central nidus.

At operation on October 27, 1953, a bone tumor was identified anterior to the right greater trochanter. The base of the excised block revealed a soft, red, pea sized center. The tumor was excised en bloc (Fig. 2).

Pathological Findings. A fragment of bone which consists of cortical and cancellous bone was received. A small cystic area was present near the center of the specimen (Fig. 3). The entire specimen measured 3.5 cm. in diameter and the small cystic center 0.9 cm. Microscopically one section showed fibrous tissue replacement of the bone marrow. The other section showed a sharply defined lesion in the cancellous bone with abundant osteoid and irregular well calcified osseous spicules encased in a highly vascular and moderately cellular connective tissue. Osteoclasts were present in moderate numbers (Fig. 4). The diagnosis was osteoid osteoma.

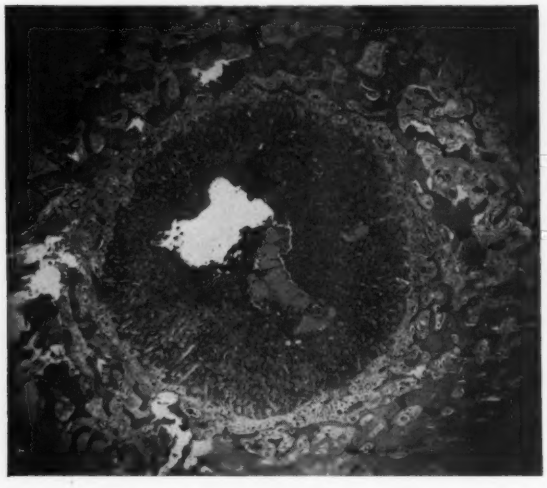

Fig. 3. Case 1. Low magnification view showing the well defined nidus. Clear area is an artefact.

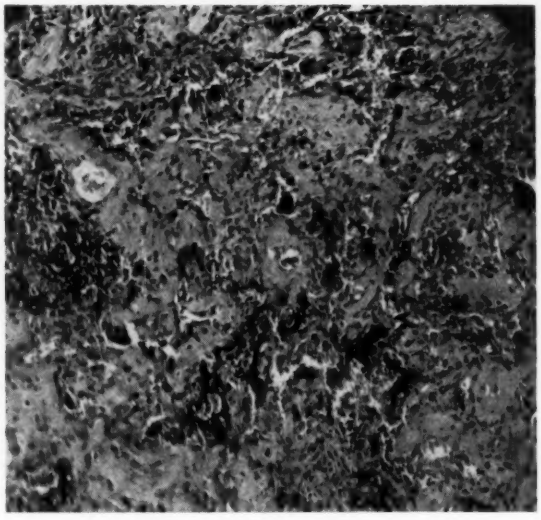

Fig. 4. Case 1. Photomicrograph shows masses of osteoid, giant cells, immature spicule formation.

The postoperative course was uneventful and the patient was discharged on November 8, 1952, without pain.

A lateral film of the right hip taken postop-

Fig. 5. Case 1. Postoperative roentgenogram. Excision site demonstrated.

eratively showed the site of surgical excision (Fig. 5).

Case II. P.R., a twenty-nine year old white male admitted on April 22, 1953, with a chief complaint of pain in the right hip of one year's duration. The pain had become more severe and at the time of admission required aspirin gr. 10, every four hours. Pain was localized to the hip at all times. There was some limitation of motion particularly flexion and abduction. During this period he had had numerous roentgen examinations by competent radiologists.

On physical examination, he was well developed, well nourished, and appeared in good general health. Temperature was 37° C. There was slight muscle atrophy around the right hip, and slight limitation of motion on flexion and abduction. Laboratory findings: Urine was normal. P.P.D. negative. Routine blood studies were normal. Kline test negative. Films of the right hip were interpreted as follows: "There is osteoporosis involving the bones of this region. In the lateral view on the anterior margin at the junction of the head and neck, there is an area of cortical destruction." A septic or tuberculous arthritis was considered the most likely diagnosis (Fig. 6).

Fig. 6. Case II. Lateral view of right hip. Subperiosteal dense nidus with rim of radiolucence.

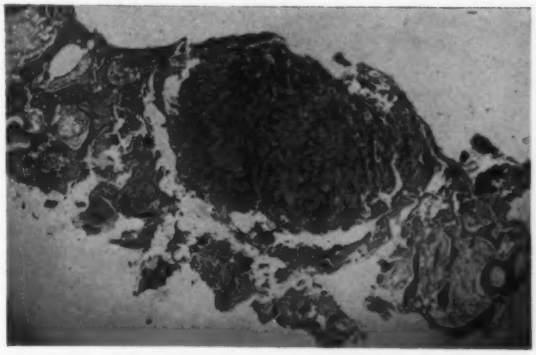

Fig. 7. Case II. Low power view of the nidus.

The preoperative diagnosis was osteoid osteoma. At operation on April 28, 1953, through an anterior incision the capsule was opened and 10 cc. of clear amber fluid was withdrawn for culture and smear. A biopsy of the capsule was taken because of granulation tissue in the joint. A roughened area on the anterior portion of the femoral neck was excised en bloc.

Microscopic examination of two sections of synovial membrane showed the superficial layers to be infiltrated by a moderate number of round cells. One section of bony tissue showed a central circular mass composed mainly of osteoid tissue. This central mass contained more bone spicules than the surrounding normal bone. These spicules were made up of varying degrees of mature and immature bone, lined by osteoblasts. The surrounding marrow showed a considerable amount of fibrous connective tissue (Fig. 7). The final diagnosis was osteoid osteoma and chronic synovitis.

The patient was discharged on May 8, 1953, without pain.

Case III. I.C., a twenty-nine year old white female admitted on August 11, 1953, with a chief complaint of pain in the left hip of ten months' duration. The pain at first was occasional but had become progressively worse, particularly in the past two months. There was no particular motion of the leg which aggravated the pain, but motion did aggravate it. Weight bearing at times was associated with an increase in the pain. On physical examination she was well developed, well nourished, and appeared in good general health. There was no fever. When first examined there was point tenderness over the anterior hip joint but this did not persist. There was no limitation of mo-

Fig. 8. Case III. Anteroposterior roentgenogram of left hip. The central area of radiolucence is well shown with its surrounding bony sclerosis.

tion of this hip. Laboratory findings: Urine was normal. Blood cell counts showed a mild anemia. Kline test negative. Roentgen examination revealed a 1 cm. area of radiolucence on the anterior surface of the neck of the femur with a surrounding zone of sclerosis. This had the typical appearance of an osteoid osteoma (Fig. 8).

The preoperative diagnosis was osteoid osteoma. On August 12, 1953, the capsule of the left hip was opened and a large amount of yellow fluid was encountered in the joint. Subsequent culture of this fluid was negative. The synovia showed a few fibrous tags. On the anterior surface of the neck of the femur just below the articular margin a raised, hyperemic, circular area was found which was excised en bloc.

Microscopic study revealed multiple fragments of bone showing distortion of the trabecular pattern. One section showed considerable amounts of osteoid. There are irregular trabeculae of mature and immature bone lined by osteoblasts. Between the osteoid tissue there was a diffuse infiltration with young fibroblasts. The diagnosis of osteoid osteoma was confirmed.

The patient was discharged on August 24, 1953 free of hip pain.

DISCUSSION

General Findings. The general findings of these cases are typical, and correspond well to those previously described in detail.[2,3,4] The age groups involved usually include adolescents and young adults. In this group, the age range was 22–29 years; none of the patients had systemic symptoms or signs, and the duration of symptoms varied between ten and twelve months. Pain was at first occasional but later constant, and always well localized to the hip joint. The relief of pain following surgical excision was almost immediate. No masses were palpable, as in cases where a marked periosteal reaction is present.

Physical Findings. The physical findings were those of (a) point tenderness over the lesion, (b) slight limitation of motion particularly on flexion, and internal and external rotation, and (c) minimal muscle atrophy. These findings are consistent with a subacute arthritis.

Laboratory Findings. Laboratory findings were not abnormal, including negative smears and cultures from the capsular fluid in the last 2 cases.

Roentgen Findings. In 58 cases described by Morrison *et al.*[6] the two most frequent types of central nidus were (1) the radiolucent center and (2) the dense center with a clear rim. In the same series the three most frequent locations were cancellous bone in 24, cortical bone in 19, and subperiosteal bone in 7. There is general agreement that the cancellous lesions provoke less surrounding sclerosis. There is a difference of opinion as to whether the lesion starts with a dense center or radiolucent center.[4,7] The appearance of the lesion cannot be correlated with the duration of symptoms.[6]

Roentgenographically these 3 cases were entirely different in their appearance. Case 1 showed a rounded subperiosteal bony protuberance. This patient had been examined by roentgen ray repeatedly and a diagnosis had not been made. On reviewing these

these films the exophytic area could be seen to grow progressively larger over a period of six months. There was no surrounding sclerosis. This appearance resembled Case 8 of Jaffe[4] which was localized on the phalanx. Our Case II was an excellent example of the difficulties in roentgenographic diagnosis and in the important differential diagnoses. At the first studies only regional osteoporosis was reported and at the second study a small area of cortical destruction, which suggested a septic or tuberculous joint, was reported. This area was actually a small subperiosteal cortical nidus density surrounded by a thin halo of radiolucency. Case III showed a lesion typical of osteoid osteoma reported in the long bones with a small central radiolucency surrounded by cortical sclerosis.

Pathological Findings. This lesion is regarded as being a benign osteogenic tumor even though it is of self-limited growth. Pathologically the nidus in all 3 cases was between 1 and 2 cm. The microscopic picture was entirely similar, with the variants being the degree of organization and calcification of the osteoid, the numbers of giant cells present, and the amount of sclerosis involving the surrounding bone. The basic pathological pattern is the osteoid in a background of vascular and cellular tissue. The cells consist of osteoblasts, a few osteoclasts, large numbers of fibroblasts and occasional giant cells. Trabeculation was extremely variable. In Cases II and III varying amounts of yellow synovial fluid was present associated with a chronic synovitis.

COMMENTS

The need for good lateral roentgenograms of the hip is apparent for the proper diagnosis of this lesion.

We are now interested in the problem of the relationship between the oval areas of focal bone sclerosis seen in the femoral neck of older asymptomatic persons and the osteoma phase of osteoid osteoma. Of particular interest in this regard is one case[9] which was followed for twenty-four years and at the end of this period showed sclerosis and cortical thickening.

SUMMARY

1. Three cases of osteoid osteoma involving the femoral neck have been described and discussed.

2. The importance of the location of the lesion in producing symptoms, signs, and roentgen manifestations of hip joint disease has been stressed. The two intracapsular lesions had an associated chronic synovitis.

3. Each case presented a different roentgenological picture: (a) exophytic subperiosteal bone tumor with a radiolucent nidus; (b) subperiosteal dense nidus with a clear rim of radiolucency; (c) central cortical radiolucent nidus with surrounding sclerosis.

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ROENTGEN KYMOGRAPHY OF THE DIAPHRAGM*

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ROENTGENOLOGIC investigation of the diaphragm is accomplished usually either by roentgenoscopic inspection, by roentgenograms made in inspiration and expiration, or by both techniques.[5,9,22] These methods have the disadvantages of reliance on fleeting visual images insofar as roentgenoscopy is concerned, and of fixed records insofar as roentgenograms are involved. Even with optimum accommodation and careful scrutiny it is difficult to evaluate roentgenoscopically the forms and time of the wave-like motions of the diaphragm. Film records reveal only the stopped contours, inspiration and expiration roentgenograms merely serving to identify the form and position of the diaphragm at a particular moment.

These disadvantages can be minimized if in addition to other methods roentgen kymographic recordings of the diaphragm motion are made during a standardized type of respiration. The present study is directed at investigating the movements of the normal diaphragm as well as observing the effects of various intrathoracic and subphrenic conditions.

TECHNIQUE AND MATERIAL

Roentgenograms were first obtained in the frontal, the lateral and, when deemed desirable, in the oblique positions. Roentgen kymograms were made in similar positions. Roentgen kymograms were made in similar positions, using the Liebel-Flarsheim multiple slit kymograph. The grid was arranged so that the lead strips were perpendicular, permitting the recording of a strip of film 12 mm. wide. The exposures were made while the cassette moved through its entire range and the patient breathed moderately and steadily. Each frame thus recorded the motion of single points on the diaphragm 13 mm. apart. Respiration was rehearsed with each patient so that undue heavin or other extraneous movements were avoided. The exposures lasted three seconds, permitting the recording of from 1.5 to 3 waves. This was found to provide more easily interpreted curves than roentgen kymograms of 5 or 6 waves, or of less than 1 full wave.

The material consisted of over 100 normal individuals, about half of whom were healthy young adults. The others, who had no complaints referable to the chest, had been referred for routine chest studies in the course of hospitalization. Table 1 indicates the range of the clinical material and the number of cases in each category.

TABLE I

Normals—100 cases
Scalloped diaphragms, including multiple small waves and single or double large waves—40 cases
Eventration of the left diaphragm—3 cases
Emphysema—10 cases
Pneumothorax, complete—3 cases; incomplete—3 cases
Pleural effusion—30 cases
Basal pleuritis—20 cases
Pneumonia—10 cases
Atelectasis—10 cases
Pulmonary neoplasms, primary—25 cases
Pulmonary neoplasms with mediastinal extension—20 cases
Mediastinal tumors—15 cases
Subphrenic abscesses—right, 12 cases; left—6 cases
Postoperative cholecystectomy—8 cases
Postoperative gastrectomy—3 cases.
Postoperative phrenic crush for hiatus hernia—3 cases
Liver metastases—25 cases
Splenomegaly—10 cases
Pneumoperitoneum, postoperative—10 cases; spontaneous—1 case
Hepatodiaphragmatic interposition—1 case
Right-sided hiatus hernia—1 case
Right renal neoplasm—1 case

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LITERATURE

Roentgen kymography was described in 1911 by Sabat. His work was continued by others who devised single or double slit kymograms which were utilized principally for studies of heart motion. It was not until Stumpf[19] developed the multiple slit kymograph that the technique achieved a clinically useful aspect. The physical basis for roentgen kymography was clearly elucidated by Schwarzschild.[20] Greatest attention has been accorded the roentgen kymographic investigation of the heart action, and some work has been described on the kymography of other moving organs such as the stomach, the intestine and the tracheobronchial tree.

The diaphragm has received relatively little attention even though its suitability for roentgen kymographic study was recognized early. Scott and Moore[16] quote Dahm and others as observing restricted diaphragmatic movements in subphrenic and perinephric abscess, acute cholangitis and ascites. In a report on 30 cases, Scott and Moore indicate roentgen kymographic alterations in movements of the diaphragm in patients with lobar pneumonia, lung abscess, lung cysts, lung tumors, bronchiectasis, atelectasis, phrenicectomy, tuberculosis and intra-abdominal lesions, diaphragmatic adhesions and emphysema.

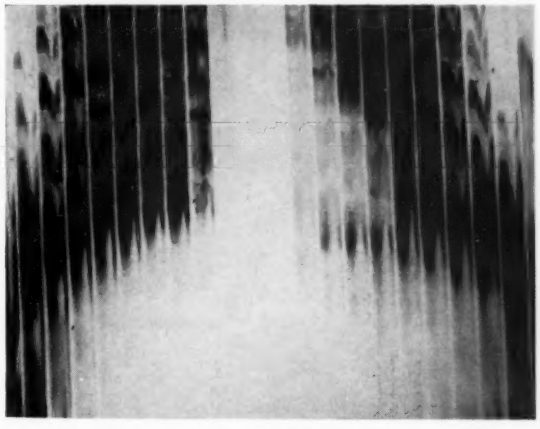

FIG. 1*A*. Posteroanterior roentgen kymogram of normal diaphragm showing one complete wave of inspiration and expiration. The respiratory wave is slightly more marked in the periphery of the diaphragm.

FIG. 1*B*. Same case as Figure 1*A*; right lateral kymogram. The motion of the anterior half of the diaphragm is rather less than half of the posterior half. Note the respiratory movements of the sternum anteriorly and of the thoracic vertebrae posteriorly.

Observations on roentgen kymography of the diaphragm after phrenicoexeresis were mentioned by Sisti and Soricelli,[18] who described it as useful in observing the effects of this operation. Di Lauro and di Guglielmo[6] investigated the kymographic aspects of diaphragm movement in cases of silicosis, and noted no significant change. Tu and Hsieh[21] mentioned that roentgen kymograms of the diaphragm showed restricted motion in the vicinity of a tuberculoma imbedded in the diaphragm. McLaren[14] also briefly indicated the advantages of roentgen kymography in the evaluation of diaphragmatic movement. The subject received more detailed attention in the monograph of Stumpf, Weber and Weltz.[19]

ANATOMY OF THE DIAPHRAGM

The diaphragm is composed of three leaves, a right, middle and left leaf. The right is the largest, the middle next in size and the left is the smallest. Three openings are usually present

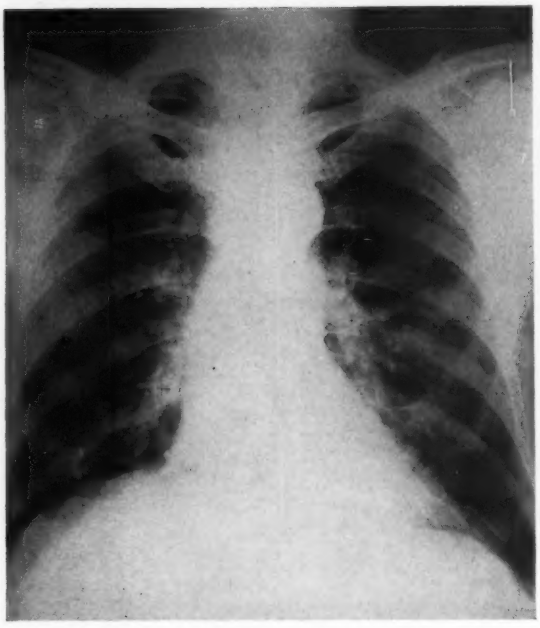

Fig. 2*A*. Normal chest teleroentgenogram showing multiple small scallops of the right leaf of the diaphragm.

in the middle leaf for the passage of the aorta, the esophagus and the inferior vena cava. In addition, variable defects in the central tendon of the sternal portions and the anterior aspects of the lateral leaves are sometimes present.

The muscles of the diaphragm originate from the circumference of the thorax and insert into fibrinous central tendon. They are grouped according to their sites of origin as sternal, costal and lumbar muscle groups. The central tendons are situated near the center of each leaf in a rather anterior position so that the posterior muscle bundles are longer than the others. The central tendon blends with the pericardium, and is composed of several fibrinous tissue planes set at varying angles one to the other. When the diaphragm is spread out the central tendons form a clover leaf-like pattern. Bundles of fibrous tissue sometimes produce indentations in the muscular wall of the diaphragm, producing the roentgenographic picture of multiple scallops. The amount of fibrous tissue and the relative strength of the central tendons may vary, resulting in upward protrusion of a portion of the diaphragm in which the muscle is relatively deficient. This usually occurs in the central and anterior aspects of the diaphragm, rarely in the posterior aspect. A bilobed or trilobed appearance of the diaphragm may result. I have observed this change only occasionally in the left diaphragm, and quite often in the right.

Roentgenographically the normal diaphragm presents a bilobed dome-shaped configuration defining the lower margins of the thoracic cavities. The heart shadow effectively obscures the middle leaf. As seen in the posteroanterior view, the lateral costophrenic sinuses are approximately at the level of the tenth interspace, while the uppermost portions of the diaphragm are approximately at the eighth interspace posteriorly. In the vicinity of the heart on the right side a less prominent declivity, the cardiohepatic angle, is seen. Medial to this the diaphragm tapers downwards to merge with the medial lumbocostal arch uniting with the right crus which then blends with the anterior longitudinal ligaments of the spine. The left side of the diaphragm also swings downwards in its medial aspect to form the left crus. The leaves are usually at approximately the same level, but the right may be slightly higher than the left. On the other occasions the left diaphragm may be slightly elevated by underlying gaseous distention of the stomach or the splenic flexure.

The innervation of the diaphragm is from the phrenic nerve containing fibers from the fourth cervical nerve and branches from the third and fifth cervical nerves.

The major portion of the respiratory act is performed by the muscular efforts of the dia-

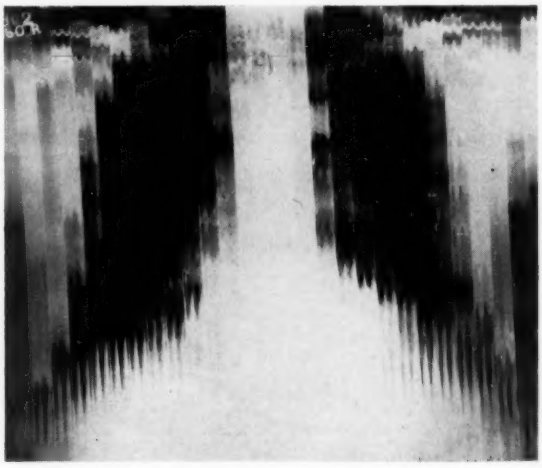

Fig. 2*B*. Same case as Figure 2*A*; posteroanterior roentgen kymogram of diaphragm showing two full waves of respiration. The wave pattern on both sides is normal.

phragm. This musculotendinous sheath may be divided into two functionally different parts, a costosternal portion which moves downwards and forward to push the abdominal viscera before it, thereby increasing the capacity of the lower thorax. At the same time the spinal or crural parts act to increase the vertical diameter of the chest during inspiration. In expiration the diaphragm moves upwards. Its movements are under voluntary as well as involuntary control, and produce a negative pulmonary pressure during retraction as well as an expulsive pressure in its ascent.

ROENTGEN KYMOGRAPHIC OBSERVATIONS

The Normal Diaphragm. Depending on the rapidity of respiration, from 1 to 3.5 respiratory waves were recorded in a three second interval. The posteroanterior roentgen kymograms depicted the diaphragmatic excursions as inverted "V" shaped waves, the ascending leg corresponding to the expiratory phase and the downward leg to the inspiratory effort. The former was designated for convenience as the "E" leg and the latter the "I" leg. In more than two-thirds of the cases studied the peaks of these waves were sharp and even, and the "E" and "I" legs were symmetric in their angles of ascent and descent. In others a notch was present about half way up the "E" leg, and in a few instances a similar notch was present in the "I" leg. Occasionally a slight blunting or rounding of the apex of the respiratory wave was present, while in rare instances a step-like pattern was present in the "E" leg.

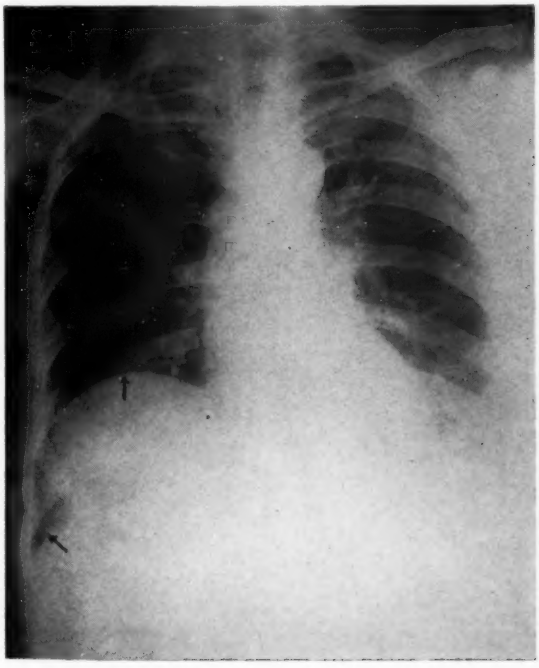

Fig. 3*A*. Normal chest teleroentgenogram showing two large scallops of the right diaphragm (upper and lower arrows).

Fig. 3*B*. Same case as Figure 3*A*; right lateral view. The right anterior aspect of the diaphragm shows a marked upward bulge (arrows).

For the purposes of analysis the diaphragm was divided into lateral, medial and inner thirds. The heights of the respiratory waves varied from patient to patient, the extremes being 1.5 cm. to 6 cm. and the average between 2.5 and 4 cm. The lateral and middle thirds of the left diaphragm sometimes had a higher amplitude of movement than the right, but this was considered a normal pattern. More often both leaves moved equally, and occasionally the right had a higher range of movement than the left.

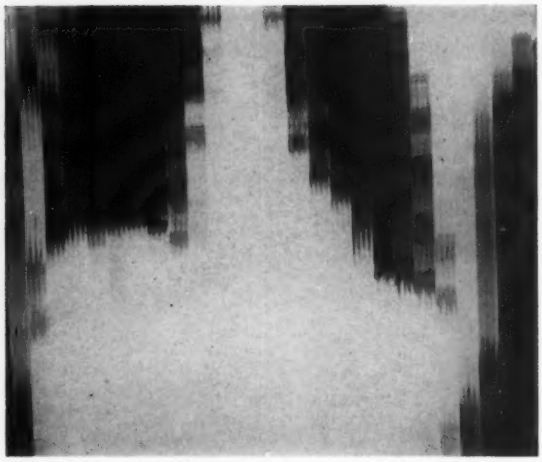

Fig. 3*C*. Same case as Figures 3*A* and *B*. Posteroanterior roentgen kymogram of diaphragms reveals moderate diminution in the motion of the upper scallop of the right diaphragm.

The respiratory motions of the diaphragm could be seen to be superimposed on the heart pulsations. The diaphragmatic movements were also clearly reflected in the movement of gas and fluid in the stomach so that the images were almost exactly alike. This proved helpful in identifying the position and range of motion of the left diaphragm when that structure was hidden by fluid in the thoracic cavity. Administration of a carbonated beverage before taking the kymograms was a definite diagnostic aid in selected cases. Reflected movements could also be observed in loops of gas-filled intestine and the lower edges of the liver and spleen.

Roentgen kymography also affords an excellent method for recording the respiratory motions of the ribs. During inspiration the ribs ascend while the diaphragm descends, and vice versa, so that the rib waves are inverse to the diaphragm waves. The rib waves increase in amplitude proceeding from the costovertebral articulations laterally towards the mid-axillary line. The movements of the anterior ribs are not adequately seen on the posteroanterior roentgen kymograms. Readily measured waves of motion were seen in the first to the ninth or tenth ribs. The lower two or three ribs could not be seen well enough to be passed upon in this respect. The respiratory motion of the clavicles could also be observed. In the lateral roentgen kymograms the respiratory motions of the thoracic vertebrae could also be seen, confirming the observations of Wenckebach.[23]

Roentgen kymograms of the normal diaphragm made in the lateral projection showed that the movement of the posterior half of the diaphragm exceeded that of the anterior half. This diminution of motion was at first regarded as suspicious of subphrenic disease, but this supposition was negated when a patient with such a picture showed a perfectly normal liver and diaphragm at exploratory laparotomy. Oblique roentgen kymograms enable one to investigate the motion of the anterior and posterior diaphragm with a minimum of overlapping, and sometimes proved helpful in diagnosis.

Observations of the movement of the middle leaf of the diaphragm were not possible because of the cardiac shadow. However, the reflection of these waves could sometimes be observed in overexposed roentgen kymograms in the motion of the lower aspect of the heart.

"*Scalloped*" *Diaphragm*. This condition

Fig. 3*D*. Same case as Figures 3*A*, *B* and *C*. Oblique roentgen kymogram. The impairment of the pulsations of the upper scallop of the right diaphragm is better demonstrated than on Figure 3*C* (arrows).

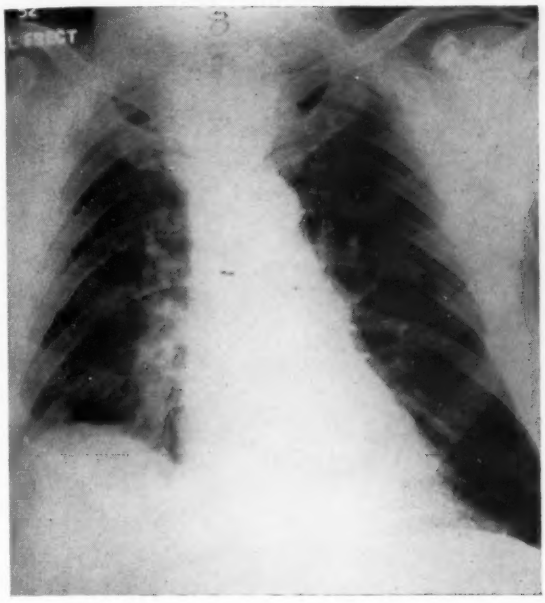

Fig. 4*A*. Teleroentgenogram of normal chest showing apparent elevation of the right diaphragm.

is included with the normal diaphragm because of its relative frequency and apparent lack of clinical significance. The term refers to the dome-shaped elevations

Fig. 4*B*. Same case as Figure 4*A*, right lateral view. The apparent elevation is due to an upward bulge of the posterior aspect of the right diaphragm (arrows).

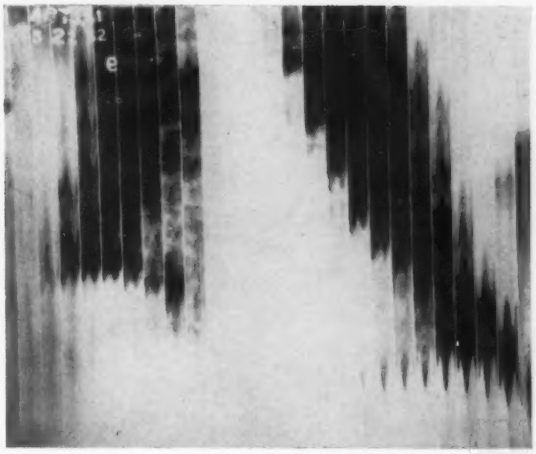

Fig. 4*C*. Same case as Figures 4*A* and *B*; postero-anterior roentgen kymogram shows apparent restriction of motion of the right diaphragm.

often seen in the right diaphragm which may present as multiple, small overlapping scallops. Less frequently, the right diaphragm may present two or three large scallops, which on lateral projections are seen to involve the middle or the anterior aspects of the diaphragm and rarely the posterior aspect.

Roentgen kymographic studies reveal

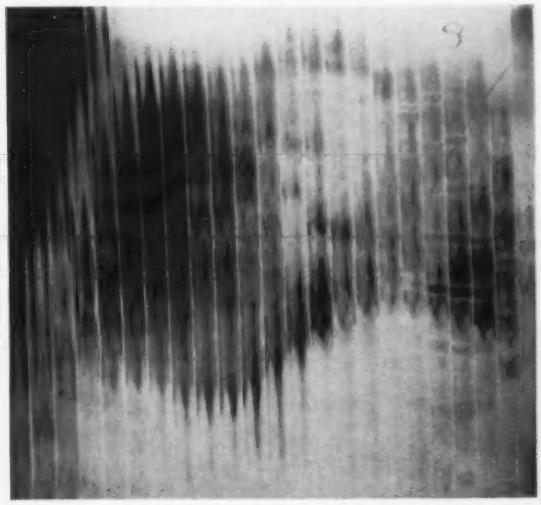

Fig. 4*D*. Same case as Figures 4*A*, *B* and *C*; right lateral roentgen kymogram of diaphragm. The movement of the posterior upward convexity of the right diaphragm is restricted as compared to the mid-portion. The movement of the anterior third of the diaphragm is about the same as the posterior third and less than the middle third.

Fig. 5. Posteroanterior roentgen kymogram of the diaphragm in a patient with eventration of the left diaphragm. The left diaphragm is elevated about midway into the left thoracic cavity. The movement of the left diaphragm is restricted, the onset of the expiratory wave lags behind that on the normal right side, and the respiratory wave is rounded and serrated. One frame is drawn in for clearer demonstration. Note the reflected waves in the gas-filled stomach (lower arrows).

that in most instances of multiple small scallops no appreciable alteration of the respiratory motion of the diaphragm is present. When large double or triple scallops were present the amplitude of motion of the uppermost aspects of the diaphragm was impaired so that these excursions were about half of the normal lateral diaphragmatic movement. The motion of the scalloped portions was in phase with the remainder of the diaphragm.

The cause for these irregularities of the diaphragm still requires investigation. Some hold that they represent muscle spasm, but this appears unlikely in view of the persistence of the scallops over long periods of time. It would appear more likely that they are due to fibrous bands interspersed with the muscle, fixing various linear segments in a scalloped pattern by restraining muscular action. In cases of

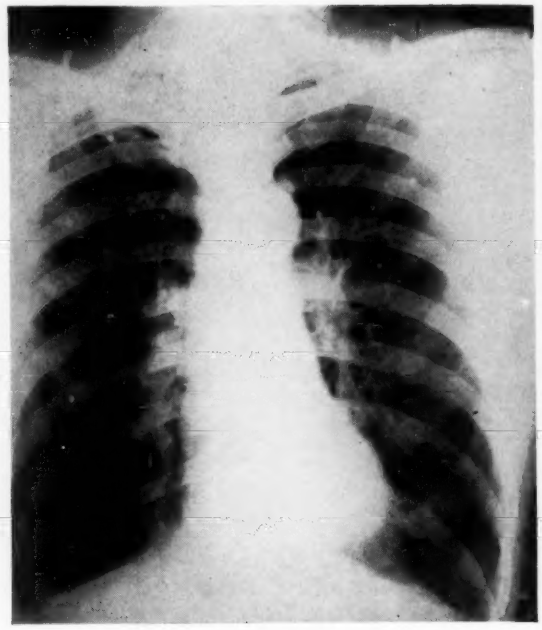

Fig. 6*A*. Teleroentgenogram of emphysematous chest. The diaphragm is at the level of the posterior aspect of the 12th rib on each side.

double or triple large scallops a more extensive replacement of muscle by fibrous tissue might be postulated. This is suggested by the restricted range of action of the involved areas, and is borne out by

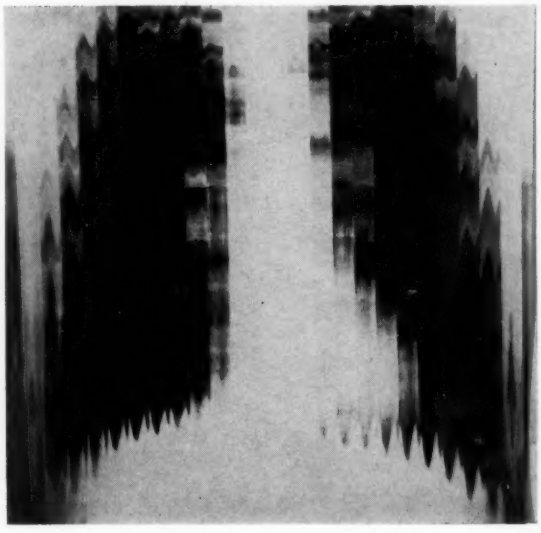

Fig. 6*B*. Same case as Figure 6*A*. Posteroanterior roentgen kymogram of the diaphragm shows good amplitude of the respiratory waves and ample motion of the ribs.

several cases which we have followed to operation, and in one recent case in an infant who was studied after pneumoperitoneum had been induced. In the last case as well as in the ones investigated at laparotomy the diaphragm was found to be thinned in the area of the scallop, and that the dome of the liver presented a similarly formed convexity following the diaphragm contour.

There were 40 cases of scalloped diaphragm in the present series. All were asymptomatic.

Eventration of the Diaphragm. As regarded in the present study eventration of the diaphragm is limited to that condition in which one leaf is elevated high into its suprajacent hemithorax, with no defect which might permit passage of viscera into the thoracic cavity.[1,3,4,7,12,13] Elevations of the diaphragm incident to diseases of the phrenic nerve are considered in a separate section. Large scallops of the diaphragm were not considered as eventrations.

Eventration of the diaphragm is considered a congenital malformation. According to Bayne-Jones[1] the intact diaphragm consists principally of fibrous tissue interspersed in which are muscle fibers which are morphologically normal. Lawler, West and Brosnan[13] noted in a case of congenital eventration that the muscle layers were replaced by fatty and fibrous tissue, and that there was disturbed development of the phrenic nerve. The incidence of eventration is infrequent, and the lesion is predominantly one of the left side of the diaphragm. Eventrations of the right diaphragm have been reported rather often in infants, but care should be taken in such cases to exclude cases of purely phrenic nerve origin.

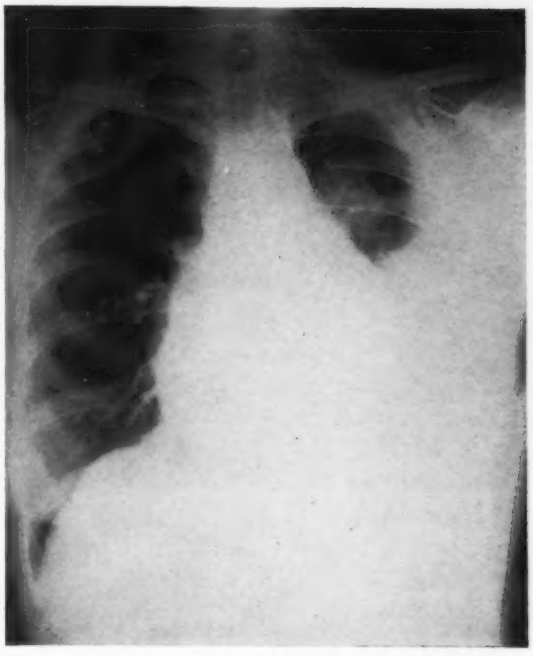

Fig. 8*A*. Teleroentgenogram of an adult woman with left hydrothorax.

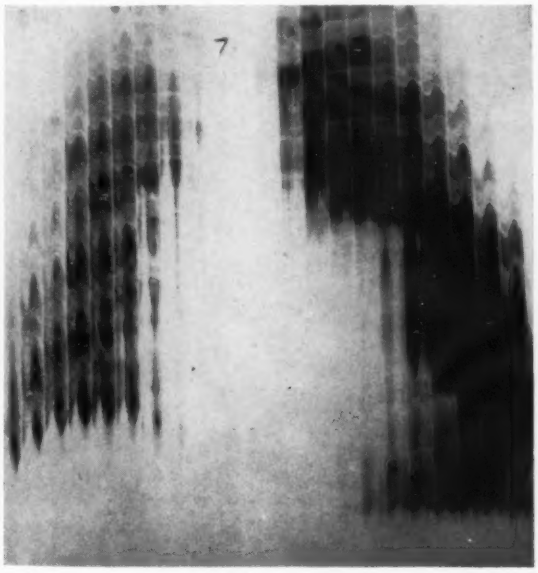

Fig. 7. Posteroanterior roentgen kymogram of the diaphragm in a patient with complete spontaneous pneumothorax on the left side. The respiratory waves of the left diaphragm are small, irregular and out of phase with the normal right diaphramatic waves.

There were 3 cases of eventration of the left diaphragm in the present series. Roentgen kymographic examination showed the movement of the right diaphragm to be normal. The elevated left diaphragm presented a most interesting type of motion. Contrary to expectation, the motion of the left leaf was not paradoxical in the sense that its movement was opposite in phase

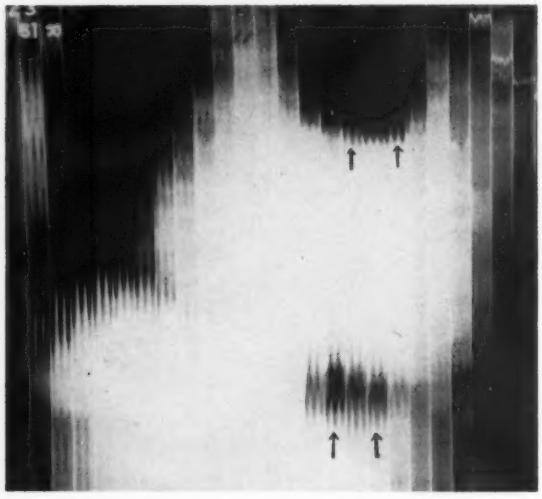

FIG. 8*B*. Same case as Figure 8*A*. Posteroanterior roentgen kymogram of diaphragm after the patient had been given a carbonated drink. Note the motion of the uppermost aspect of the fluid (upper arrows) and the motion of the diaphragm as reflected in the motion of the gas bubble in the stomach and of the fluid in the stomach (lower arrows).

to the right diaphragm. The respiratory motion of the left diaphragm produced waves of considerably diminished amplitude with blunt, broad configurations and irregularly serrated convexities. The inspiratory waves were blunter and more sloping than the expiratory waves. The time of onset of the inspiratory waves appeared to lag behind the corresponding waves on the right side.

Emphysema. Roentgen kymograms of the diaphragm were made in 10 cases. In each of these the level of the dome of the diaphragm was at or below the eleventh rib. The motion of both leaves of the diaphragm during respiration was synchronous, and the amplitude of the waves was between 2 and 3 cm. in height. The wave forms were normal. The motions of the ribs during respiration were somewhat reduced in amplitude but no change in form or time of movement was observed.

Pneumothorax. Roentgen kymograms of the diaphragm were made in 6 cases, 3 with complete and 3 with partial pneumothorax. In the latter 3 no change in diaphragm motion was observed. In the former group 1 patient showed a definite diminution in the amplitude of the diaphragm motion on the involved side, but the waves remained sharply pointed. Another patient presented diminished, flattened waves together with some restriction of rib motion on the involved side. The

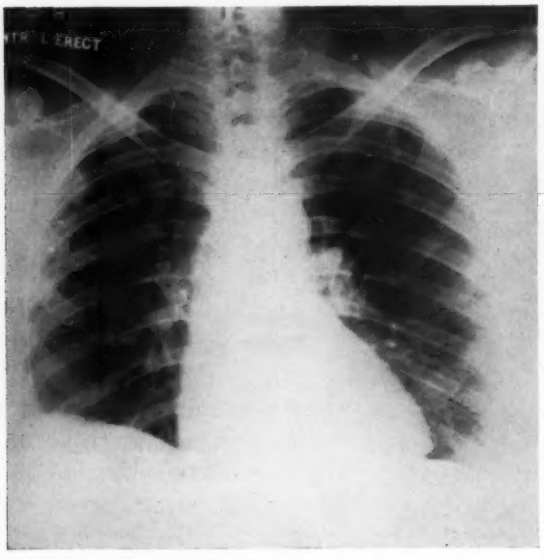

FIG. 9*A*. Teleroentgenogram of the chest of an adult male with old basilar pleurisy elevating the lateral aspect of the right diaphragm, obliterating the costophrenic sinus.

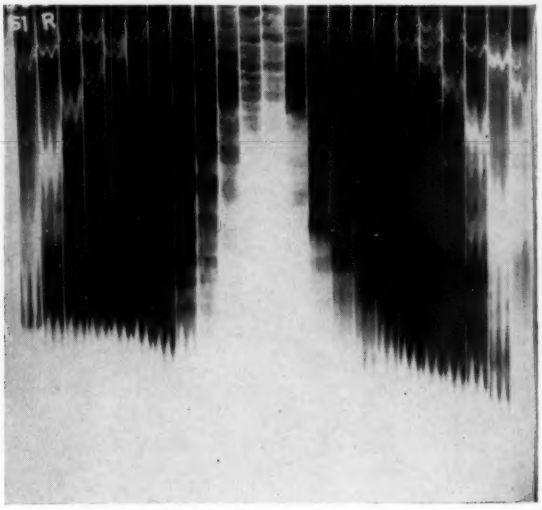

FIG. 9*B*. Same case as Figure 9*A*. Posteroanterior roentgen kymogram of the diaphragm shows moderate restriction of the respiratory wave of the lateral aspect of the right diaphragm.

third patient had reduced, flattened waves which returned to approximately normal configurations and amplitude within a few hours even though the pneumothorax was unchanged.

Pleural Effusion. Roentgen kymograms of the diaphragm were made in 30 cases of pleural effusion of varying degree. The causes of the effusions included congestive heart failure, pneumonia, rib and pleural metastases and pulmonary infarction. Included in this group were 8 cases in which the fluid on the right side simulated an elevated diaphragm. These were readily distinguished by the shift of the fluid on lateral recumbent roentgenograms. The roentgen kymograms in this group showed no restriction of motion or change in wave forms, the supradiaphragmatic fluid reflecting the motion of the diaphragm faithfully.

With slight or moderate pleural effusion, the motion of the diaphragm was transmitted to the superior aspect of the pleural effusion to a considerable extent. In instances where more advanced pleural effusion reached above the middle of the chest the diaphragm motions were damped out by the overlying fluid. In the presence of even pronounced left pleural effusions which obliterated the shadow of the left diaphragm, it was found helpful to give the patient a carbonated beverage or some barium to mark out the fluid level of the stomach and the dome of the cardia in contact with the inferior surface of the left diaphragm. Roentgen kymograms in such cases often showed the location and range of motion of the left diaphragm as reflected in the stomach content and gas bubble motions. Similar reflections were also observed in loops of bowel.

Fig. 10*A*. Teleroentgenogram of an adult male patient with right basilar pneumonia and pleural effusion. The fluid simulates elevation of the right diaphragm. A right lateral recumbent film (not illustrated) showed flow of the fluid into the lateral aspect of the chest.

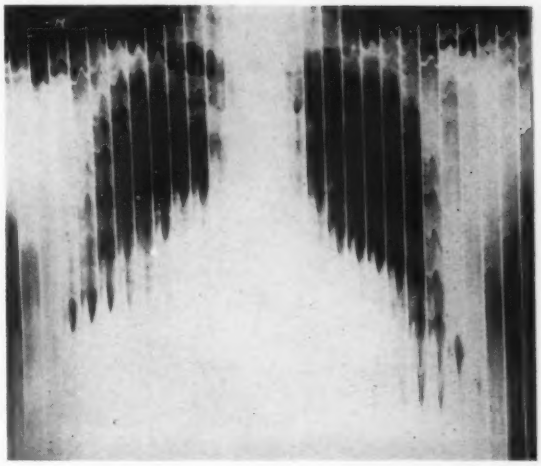

Fig. 10*B*. Same case as Figure 10*A*. Posteroanterior roentgen kymogram of the diaphragm shows ample motion of the supradiaphragmatic fluid paralleling the movement of the diaphragm. Note that the upper portion of the pneumonic area likewise shows a wide range of movement during respiration.

Basal Pleuritis. Included in this group of 20 cases were instances of pleuritis following pneumonia, congestive heart failure and tuberculosis. The motion of the diaphragm was found to be relatively unimpaired in the presence of moderate adhesions. However, if heavy adhesions were present the diaphragm motion was impaired, particularly at its periphery.

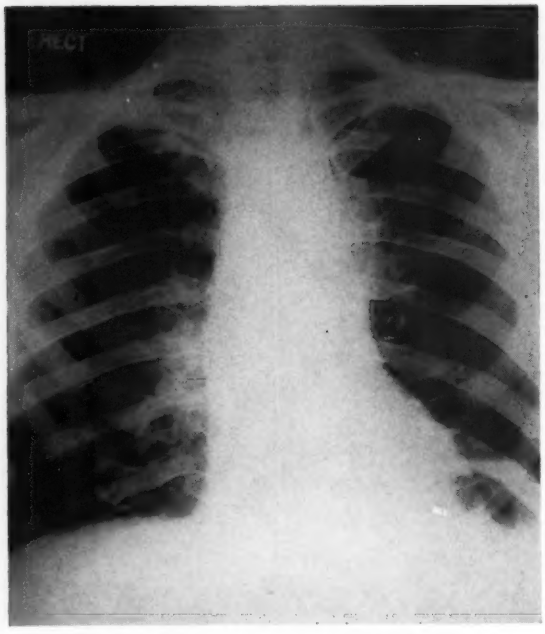

Fig. 11*A*. Teleroentgenogram of the chest of an adult male with a left paramediastinal bronchogenic carcinoma. The left diaphragm is moderately elevated.

Pneumonia. In 10 cases no change in the motion of the diaphragm was observed with involvement of the upper lungs. In 4 cases with lower lobe involvement without pleural effusion the diaphragm also moved normally.

Atelectasis. Included in this group were cases of atelectasis associated with bronchiectasis of the lower lobes, and of the middle right lobe and lingula of the left upper lobe. These patients had neither pleural effusion nor change in the position of the diaphragm. In those instances with considerable thickness of tissue above the diaphragm, restriction of motion was noted. In cases of middle lobe atelectasis alone no change in motion was seen.

Pulmonary Neoplasms. Included in this series were 25 cases of bronchogenic carcinoma with no demonstrable mediastinal extension, and 20 with definite mediastinal involvement. The former group, as a rule, showed no change in the motion of the diaphragm except in those cases of lower lobe growths with consolidation and pleural effusion where diminution in the waves of the diaphragm were noted.

The cases with mediastinal extension were of particular interest. Of these, 10 showed a definite restriction in the amplitude of motion of either the right or left diaphragm. The position of the involved diaphragm was either elevated moderately or was approximately normally situated. The wave forms in those with impairment of diaphragmatic movement presented rounded configurations, and a lag in the onset of the expiratory wave quite similar to that seen in cases of eventration was present. No paradoxical motion was observed. It was believed that this indicated impairment of the phrenic nerve.

Mediastinal Tumors. There were 15 cases in this group, including lymphomas, metastases from tumors other than pulmonary neoplasms, a neurofibroma and several postoperative mediastinal-pleural collections of fluid. In 5 cases restriction of one diaphragm with rounding of the waves and lagging of the onset of the inspiratory waves were noted. The configurations of these waves were much the same as seen

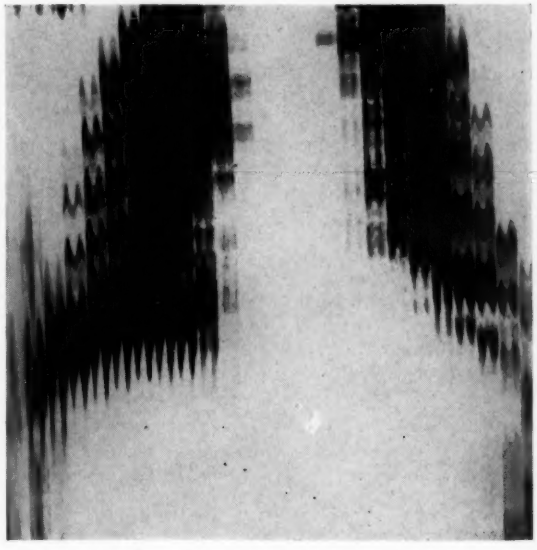

Fig. 11*B*. Same case as Figure 11*A*. Posteroanterior roentgen kymogram of the diaphragm shows definite restriction of motion of the left diaphragm with a perceptible lag in the onset of the expiratory wave.

with eventration and pulmonary tumor mediastinal metastases.

Subphrenic Abscess. There were 18 cases in this group, of which 12 were right subphrenic abscesses, 5 left and 1 bilateral. These followed a variety of conditions including cholecystectomies, appendectomies, surgical procedures for bowel neoplasms and 1 case of peritonitis incident to an occult carcinoma of the jejunum and another following closure of a perforated duodenal ulcer. One case of a massive left subphrenic hemorrhage following sympathectomy for hypertension was included in this group even though it was not of infectious etiology.

Plain films showed moderate elevation of the right diaphragm in 7 cases, but in 2 of these the increased height might be considered within average limits. In 6 instances small or moderate right pleural effusion was seen. In 2, fluid levels were present beneath the right diaphragm. In the cases of left subphrenic collections the plain films showed only questionable elevation of the left diaphragm in 2 cases and definite elevation in 1 other. Slight or moderate pleural effusions were observed in 4 of these cases.

Fig. 12*A*. Teleroentgenogram of the chest of an adult male patient with a right subphrenic abscess. The right diaphragm is moderately elevated, and the pulmonary parenchyma in the right base presents increased markings.

Fig. 12*B*. Same case as Figure 12*A*. Posteroanterior roentgen kymogram of the diaphragm shows marked restriction of the respiratory motion of the right leaf.

The roentgen kymograms of the diaphragm in the cases of right subphrenic abscess showed complete absence of mobility in 3 cases. In the remaining 9 there was but moderate restriction of motion, together with variable slight blunting of the apex of the waves and a slight lag of the onset of the expiratory wave. In the cases of left subphrenic abscess similar changes were noted except for the fact that complete restriction of motion of the left diaphragm was not observed in this group. The height of the diaphragm did not necessarily indicate the degree of restriction of motion. Instances were observed in which a considerable elevation was accompanied by visible motion while lesser elevation was accompanied by severe restriction of motion.

Postoperative Cholecystectomies. There

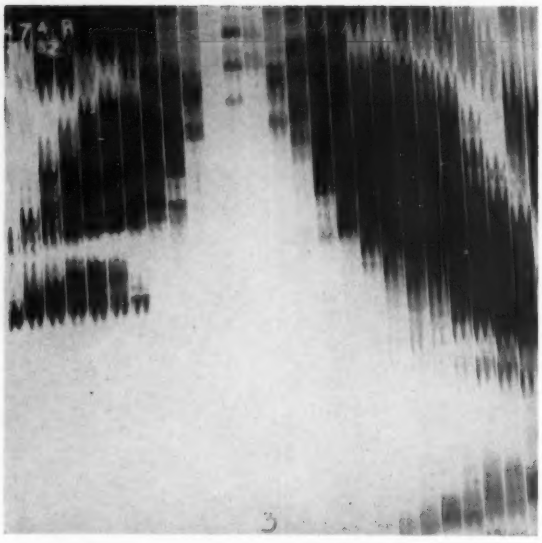

Fig. 12*C*. Same case as Figures 12*A* and *B*; posteroanterior kymogram one week later. A fluid level has appeared beneath the right diaphragm. Note the restricted movement of the right diaphragm, and the reflected waves in the fluid level.

were 8 patients in whom subphrenic collections were suspected within a few days to a week after cholecystectomy because of the clinical aspects of the postoperative course. Roentgen kymograms of the diaphragms showed slight or mild restriction of motion in 5 of these patients, and at first it was believed that the finding was of diagnostic significance. However, the subsequent course did not indicate the presence of a subphrenic collection in any of this group. A complicating factor, however, was that most of these patients were given strenuous antibiotic treatment. Perhaps this group falls into that mentioned by Meyler and Huizinga[15] who described a temporary high position of the diaphragm after cholecystectomy in several cases, postulating that inflammation may ascend to the diaphragm through the rich vascular and lymphatic circulations. This group of patients serves to warn against assuming too much in the way of diagnostic accuracy in evaluating postoperative roentgen kymograms.

Postoperative Gastrectomies. Included in this group were 3 patients in whom gastrectomy had been performed by the transthoracic and abdominal approaches. Roentgen kymograms were made because of the presence of fluid in the left thoracic cavity. In all 3, kymograms showed restriction of motion of the left diaphragm, but it was assumed that this was due to operative manipulation rather than subphrenic collections. The subsequent course of all 3 seemed to substantiate this belief.

Postoperative Phrenic Crush. Roentgen kymograms of the diaphragm were made in 3 patients in whom phrenic crush for hiatus hernia was done. The left phrenic nerve was so treated, and subsequent roentgen kymograms of the diaphragm showed definite restriction of motion in 2 instances, while in the third the diaphragm apparently retained approximately normal mobility.

Liver Metastases. Twenty-five cases suspected of liver metastases were subsequently verified. This does not take into account the much larger group of patients examined roentgen kymographically who, despite normal kymograms, later were found to have liver metastases. In the

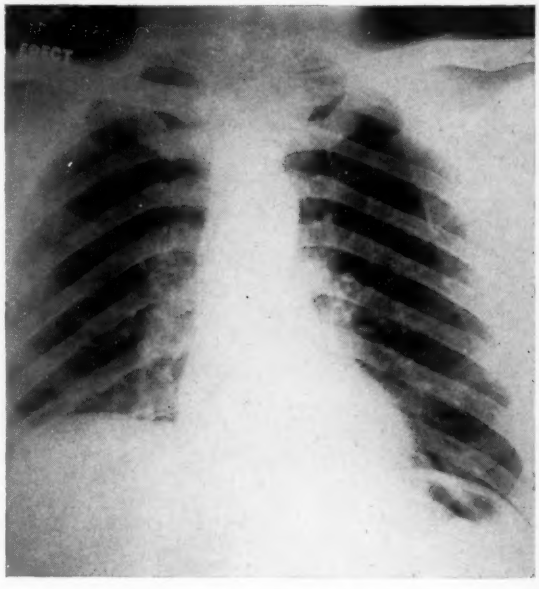

Fig. 13*A*. Teleroentgenogram of the chest of an adult male with a known carcinoma of the stomach. The right diaphragm is questionably elevated, the parenchymal markings in the right lung base are normal.

verified group were cases of metastases from carcinoma of the stomach, the colon, pancreas, breast, and kidney, as well as from sarcomatous fibroids, reticulum cell sarcomas and lymphomas. The origin of the tumor had no bearing on the roentgen kymographic picture. In those cases in which the kymograms showed restriction of respiratory motion the plain films showed only a slight or moderate elevation of the diaphragm in 8 cases. In the others the diaphragm shadows were not considered abnormal. Pleural fluid was rarely seen in this group of patients. The wave forms were similar to those seen with subphrenic collections, with diminished amplitudes, blunted tops and a lag in the onset of the expiratory wave.

Operative and necropsy evidence indicated that liver metastases affected the movement of the diaphragm only when they were bulky, with pronounced involvement of the dome of the liver. Multiple nodular implants did not, as a rule, influence the motion of the right diaphragm.

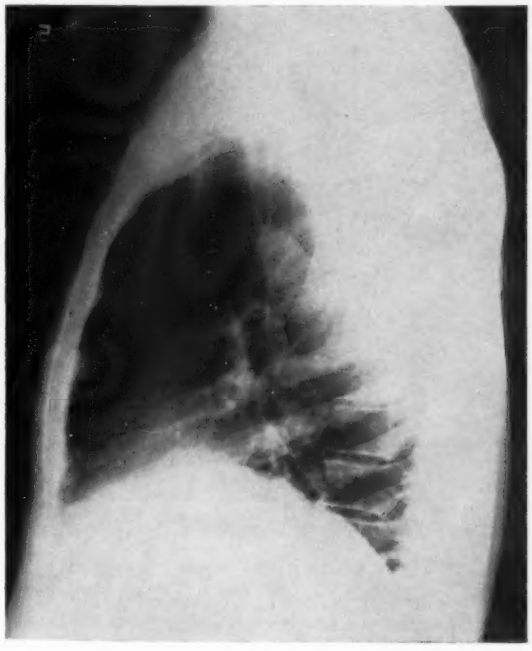

Fig. 13*B*. Same case as Figure 13*A*; right lateral chest roentgenogram showing the smooth appearance of the right diaphragm.

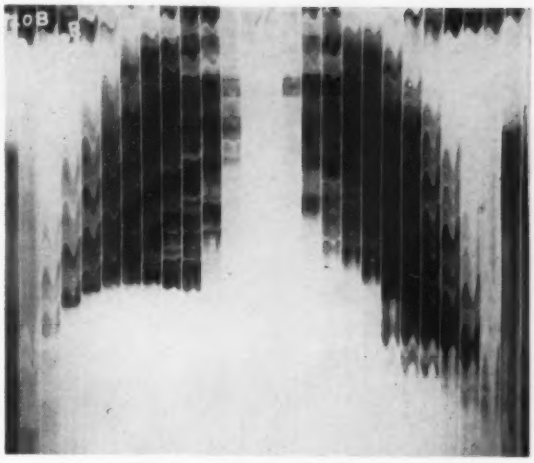

Fig. 13*C*. Same case as Figures 13*A* and *B*. Roentgen kymogram of the diaphragm shows almost complete loss of motion of the right diaphragm. This was due to a tremendous metastatic deposit in the dome of the liver.

Splenomegaly. There were 10 cases in this group, including 9 of leukemia and 1 case of splenic infarct. The latter was confirmed at operation. In 4 of these the motion of the left diaphragm was restricted, while in the others normal mobility was retained. Apparently even with advanced splenomegaly the left diaphragm may retain its normal motion.

Pneumoperitoneum. Several cases of postoperative pneumoperitoneum in which gas remained in the abdominal cavity after surgery were studied. These patients were asymptomatic, and roentgen kymography showed normal motion of the diaphragms, even when considerable gas was seen below these structures. The reflected movements of the liver and spleen as seen because of the suprajacent air were of considerable interest. These were practically of the same configuration and size as the diaphragmatic waves themselves.

There was 1 case of spontaneous pneumoperitoneum due to a ruptured duodenal ulcer. In this instance the diaphragmatic waves were irregular, but it was believed that the patient's discomfort was the more probable cause of this change.

Hepatodiaphragmatic Interposition of the Colon. One elderly male patient with this

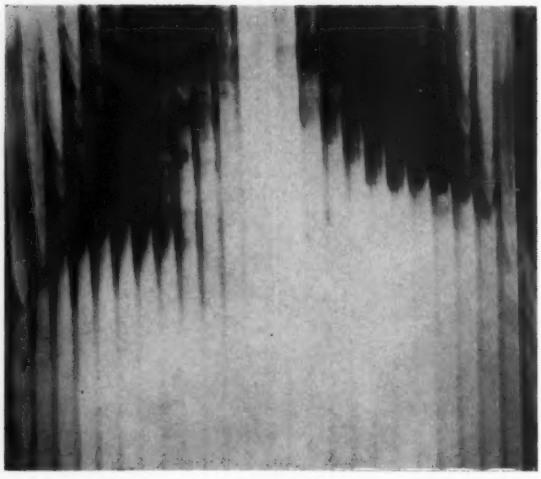

Fig. 14. Posteroanterior roentgen kymogram of the diaphragm in a patient with splenomegaly and a large splenic infarct confirmed at operation. The motion of the left leaf of the diaphragm is restricted because of the underlying mass.

condition was examined, and the roentgen kymograms of the diaphragm showed no significant change in the pattern of the waves.

Right-sided Hiatus Hernia. One woman with this condition was studied. The momotion of the right diaphragm was normal. Barium in the lower esophagus rendered this structure visible, and the respiratory waves of the diaphragm and of the lower esophagus were synchronous and equal.

Right Kidney Tumor. One patient with a massive right clear cell carcinoma showed marked restriction of the movement of the right diaphragm. This was due to the bulk of the tumor which extended up to meet the convexity of the inferior aspect of the posterior portion of the diaphragm.

SUMMARY AND CONCLUSIONS

1. Observations on the movement of the normal diaphragm in the frontal, lateral and oblique positions in adults are reported.

2. The study included roentgen kymographic studies of the diaphragm in a large variety of supradiaphragmatic and infradiaphragmatic conditions. It was found that the movement of the diaphragm persists in a relatively normal pattern in emphysema, some cases of pneumothorax, basal pleurisy, pneumonia, atelectasis and pulmonary and mediastinal neoplasms. However, impairment of the phrenic nerve may alter the form and time of the respiratory motion of the diaphragm.

3. Three cases of eventration of the left diaphragm showed that the involved leaf does not show a true paradoxical motion, but rather a lag in the onset of the wave and serration of its contour. Paradoxical motion in the sense that the left diaphragm descends while the right ascends, and vice versa, was not observed.

4. Diaphragmatic alterations in wave form in cases of subphrenic abscess, liver metastases, splenomegaly, and following cholecystectomy, gastrectomy and phrenic crush are described and evaluated.

5. Roentgen kymograms of the diaphragm in pneumoperitoneum, hepatodiaphragmatic interposition of the colon, and

Fig. 15. Posteroanterior roentgen kymogram of the diaphragm in an adult woman with a right hiatus hernia. Barium in the esophagus (arrows) follows the respiratory motion of the diaphragm. There is little impairment of the motion of the right diaphragm even though a defect was present in its anterior portion.

in single cases of a right hiatus hernia and a right renal neoplasm are mentioned.

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FIBRIN BODY FOLLOWING TRAUMATIC PNEUMOTHORAX

A PROBLEM IN DIFFERENTIAL DIAGNOSIS OF A NODULAR PULMONARY DENSITY

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FIBRIN bodies are familiar to those who have the opportunity to follow many cases of pulmonary tuberculosis under pneumothorax therapy. Since Fleischner's[3] original description, in 1922, many instances have been recorded. These spherical or ovoid masses which occur in the pleural space are of no clinical significance,[12] and have only rarely caused difficulty in diagnosis, since they have invariably been observed in tuberculous patients receiving therapeutic pneumothorax, and have usually been found resting on the diaphragm in the air-filled pleural space. The case presented here is of unusual interest because the fibrin body occurred in a nontuberculous individual, was situated in the upper portion of the chest, and prompted roentgenological consultation for differential diagnosis of a nodular density, suggesting neoplasm, in the region of the left upper lobe.

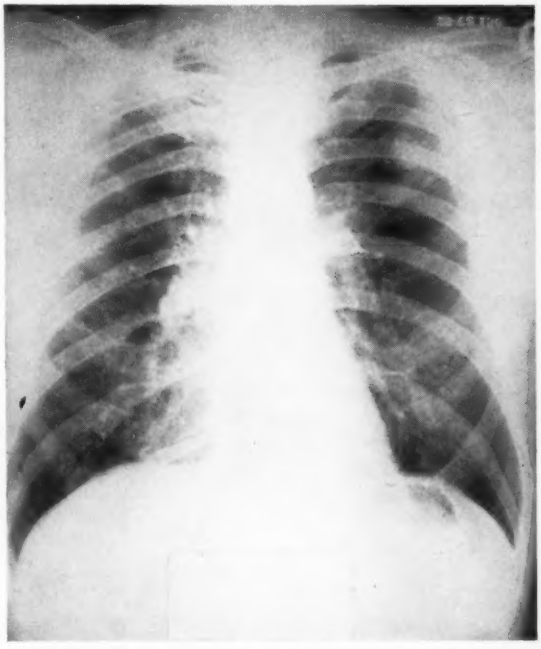

FIG. 1. Examination of October 23, 1952, showing the smoothly demarcated nodule in the left upper lung field, which was observed on routine roentgenoscopy. Other projections (not shown) localized the lesion close to the posterior portion of the sixth rib.

REPORT OF CASE

A white male, aged fifty, was referred, October 23, 1952, for roentgenographic study of the chest because of a nodular density, observed at roentgenoscopy, in the left upper lung field. This examination disclosed a smoothly demarcated nodular density, about 2.0 by 1.5 cm., in the posterior portion of the left upper lung field, adjacent to the posterior segment of the sixth rib, presumably in the superior segment of the left lower lobe or in the adjacent pleura (Fig. 1). Its margins and density were more suggestive of a pulmonary deposit than of pleural fibrosis or exudate. Old healed fractures of the left fourth and fifth ribs, without displacement, were identified at the left lateral axillary line. No evidence of fracture of the sixth rib, near the nodule in question, could be detected. There was no other demonstrable abnormality of the lungs, pleura, mediastinum, or chest wall.

Physical examination of the chest was entirely negative. No masses could be seen or palpated in the skin or subcutaneous tissues.

The patient gave a history of rib fracture with traumatic pneumothorax, the result of an automobile accident, August 30, 1952. Other than a fever of fifteen days' duration, there had been no complications. Roentgenographic examinations had been made on the day of his

injury and at intervals during the course of his convalescence. Prior to the accident, the most recent roentgen examination of his chest had been made in 1941, at which time no unusual findings had been reported. During roentgenoscopy preliminary to a gastrointestinal study, no abnormality had been noted in the lungs, March 17, 1952.

It was considered important to obtain the films made immediately after the accident, for comparison, because exploratory thoracotomy and histological examination would be indicated unless the lesion could be proved benign, within a reasonably short period of time. These films were received from the hospital, which was located in another city, on November 13, 1952. The bedside study made August 30, 1952, the day of the injury, revealed recently fractured ribs and a left hydropneumothorax, but no evidence of pulmonary or pleural nodule (Fig. 2). Subsequent films of September 5, 9, and 11 showed the hydropneumothorax loculated in the upper left lateral pleural space and disclosed the nodule in question (Fig. 3) definitely larger than in our study of October 23, 1952.

Re-examination, November 13, 1952, showed further slight diminution in the size of the

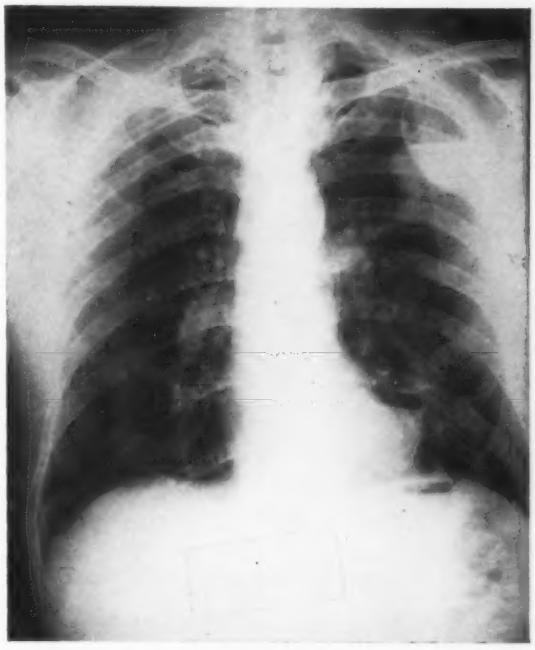

Fig. 3. Examination of September 11, 1952, twelve days after injury. The nodule, definitely larger than it appeared to be in later films, has become apparent, adjacent to a loculated left upper hydropneumothorax.

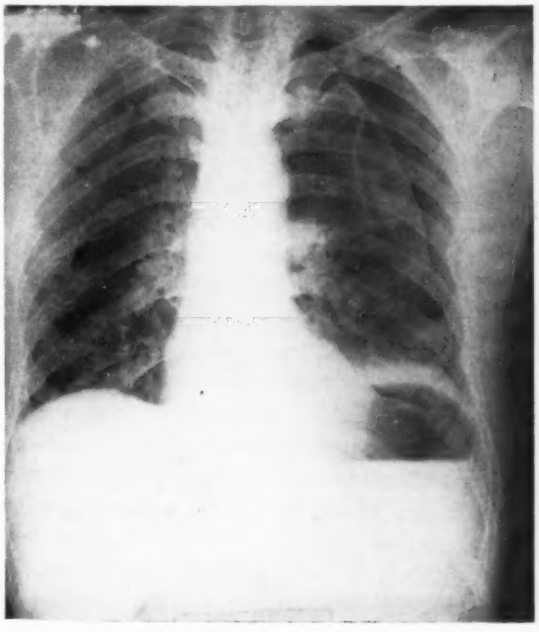

Fig. 2. Bedside examination on the day of injury, August 30, 1952, demonstrating left pneumothorax, but no evidence of parenchymal or pleural nodule.

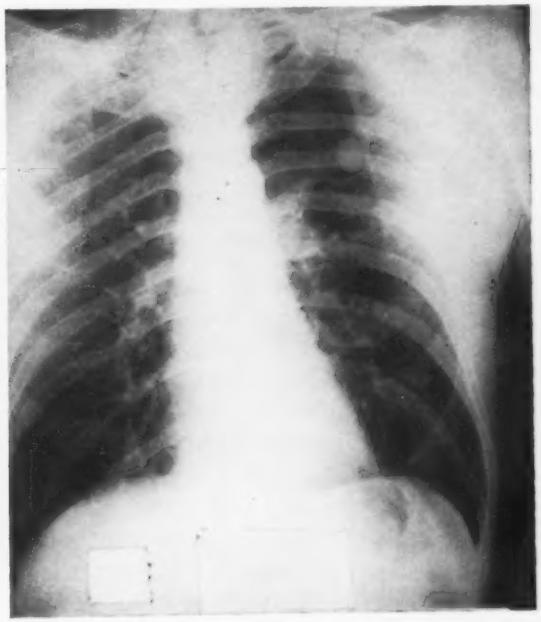

Fig. 4. Anteroposterior projection of November 13, 1952. The nodule is smaller, but still indistinguishable from a parenchymal deposit.

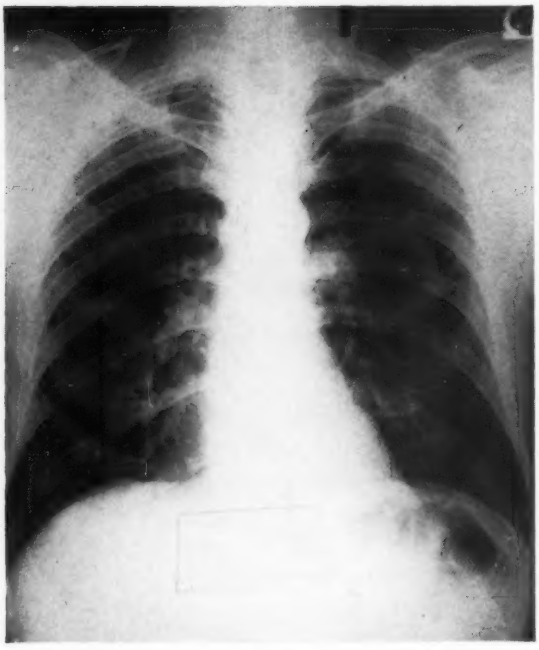

Fig. 5. January 22, 1953. The lung fields are apparently clear. A few minute densities detectable on close scrutiny of the left upper lung field, in the original film, are obscured in reproduction.

nodule (Fig. 4). In view of the definite shrinkage demonstrated, fibrin body was considered to be a safe working diagnosis, and it was deemed prudent to temporize as long as shrinkage continued. By January 22, 1953, the nodule had completely disappeared except for a few minute, nondescript, fibrotic densities remaining at its site (Fig. 5). The patient has remained asymptomatic.

DISCUSSION

Considering the wide employment of pneumothorax in the treatment of pulmonary tuberculosis, relatively little has been published concerning fibrin bodies. A search of the *Index Medicus* yielded references to only twenty-six articles on the subject, most of them in foreign languages, and all, except one, concerned patients undergoing therapeutic pneumothorax. The exception[2] deals with the production of fibrinoplastic bodies in the pleural space of dogs following injection of scharlach R and tar. The paucity of recent American or British contributions is probably attributable to the fact that the occasional appearance of these spherical exudates is anticipated and readily recognized by workers experienced in the field of tuberculosis.

Although the reported incidence varied from 2 in 700 to 4 in 328,[8] Robins and Joress[9] were able to demonstrate fibrin bodies in 16 out of 75 patients undergoing pneumothorax therapy. Origin and development appear to be best explained by deposition of fibrin on a nucleus, such as a torn adhesion or a blood clot.[14] Stöffel[14] directly examined one such mass and found it to be "yellowish in color, resembling cheesy tuberculous material, but histologically consisting of pure fibrin. No tubercle bacilli or blood elements were to be observed in it." Presumably the fibrin may originate from blood as well as from pleural exudate. Pendergrass and Neuhauser[6] describe an "interlobar hemorrhage" in a hemophiliac, which simulated a parenchymal lesion; but since the hemothorax was known to have occurred two years prior to the roentgen demonstration of the nodular density, in their case, it may be presumed that the "hemorrhage" they describe is attributable to a fibrin body of hemorrhagic origin. They make the interesting comment that a parenchymal hemorrhage would disappear much more rapidly.

Lyons[4] was able to demonstrate the mobility of these bodies while the lung is still collapsed, but he expressed no conjecture concerning their fate after re-expansion. Occasionally they become adherent to the visceral or parietal pleura, protruding into the air-filled pleural space like metastatic pleural implants.[13] According to Ballon,[1] fibrin bodies cause no discomfort and usually disappear, but *the exudate disappears first.* Rest's case[8] showed persistence for about two years after discontinuation of pneumothroax. In Zavod's experience,[15] persistence may vary from four weeks to four years after re-expansion. Although usually located near or on the diaphragm, they may be found in the upper portion of the chest. Snow,[11] Robins

and Joress,[9] and Rabin[7] have illustrated such occurrences. A fibrin body is most likely to be mistaken for neoplasm if first observed after the lung has re-expanded. Rabin points out that this error may be avoided if a previous history of pneumothorax is obtained, particularly if evidence of old pleuritis is also present.[7] If multiple, pulmonary metasases may be simulated.[10,11]

The diagnostic pitfall after the lung has re-expanded lies in the fact that the roentgenographic density of these spherical exudates is identical with that of parenchymal deposits in the lung. They cast shadows which are definitely less dense, in our experience, than those caused by localized areas of thickened pleura or pleural effusion. Their margins are not as sharply defined as those of encapsulated effusions. Pendergrass and Neuhauser stress the fact that some pleural conditions may produce shadows simulating parenchymal lesions.

In the instance presented, the history of trauma and a familiarity with the occurrence and appearance of fibrin bodies in therapeutic pneumothorax led, eventually, to a correct diagnosis. The roentgenological appearance of the nodular density in the left upper lung field was indistinguishable from that of a peripheral neoplasm. Its origin in an encapsulated effusion adjacent to the upper posterior chest wall explains its unique high position.

SUMMARY AND CONCLUSIONS

1. Fibrin bodies, usually observed resting on the diaphragm in therapeutic pneumothorax cavities, may appear after traumatic pneumothorax and may be located anywhere in the pleural space.

2. Fibrin bodies persisting after re-expansion of the lung may become roentgenologically indistinguishable from parenchymal lesions, particularly neoplasms.

3. In the differential diagnosis of nodular densities in the lung, a history of proximate trauma, particularly if associated with demonstrable pneumothorax or rib fracture, may justify postponement of exploratory thoracotomy for a period of time longer than would be a permissible in the absence of such a history.

4. A case of fibrin body, simulating a parenchymal pulmonary neoplasm, occurring in a nontuberculous patient after traumatic pneumothorax, is described.

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We are indebted to Dr. James S. Tipping for permission to report this case.

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THE MODE OF ACTION OF THORIUM X ON HUMAN SKIN*

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THE grossly visible biologic effects of erythema and pigmentation, which follow the topical application of thorium X and the therapeutic usefulness of this radioactive material in selected dermatoses are well known to dermatologists.[1,3,4,5,10,11,13,17,19,20,21] Histopathologic evidence of the biologic effect of this source of ionizing radiation was demonstrated by Naegeli and Jessner[10] as early as 1913, and later by Scholtz and Fischer,[16] Lomholt[6] and Peck[12].

Lomholt applied thorium X to areas of his own skin and later biopsied the sites exposed; in this way he demonstrated histopathologic changes as deep as 600 microns below the surface of the epidermis. These changes consisted of: in the epidermis—edema of the epidermal cells, nuclear shrinking, loss of capacity to take stains, chromatin either not taking stain or forming a highly stained clump, and complete necrosis of the older cells (*i.e.*, the uppermost ones); in the corium—cellular edema and cellular necrosis, degeneration of the connective tissue, change in appearance of fibroblasts, and vascular changes. The alterations in the corium were most prominent in the papillary bodies and here the superficial capillaries were dilated and surrounded by a cellular infiltrate. Similar microscopic changes in the papillary bodies had previously been noted by Naegeli and Jessner,[10] Lutz,[7] Scholtz and Fischer,[16] and later by Peck.[12]

The biologic effects of thorium X and its disintegration products are believed to be due principally or entirely to the alpha rays emitted. These alpha rays have a range of about 90 microns in tissue. If the action of the alpha rays predominantly emitted by thorium X is really so superficial, mechanisms responsible for the histopathologic changes which occur deep in the tissue must still be elucidated. Thus the mode of action of thorium X applied to the skin surface is still without complete explanation.

Before speculating on the mechanisms by which the alpha rays might possibly produce their biologic effects, the role of the beta and gamma rays which are also given off in the disintegration of thorium X and its daughters should be discussed (see Table I). It is the opinion of some investigators that neither the beta nor gamma rays are of any importance in producing the gross and microscopic changes which follow the topical application of thorium X. Read[14] stated that "the energy absorbed from the alpha radiation in the first 100 microns thickness of skin is of the order of 1,000 times as great as that absorbed from the beta radiation, while the gamma ray energy absorbed per cc. in this thickness is quite negligible."

In order to study this problem, Lomholt[6] applied a thin layer of gutta-percha, sufficient to absorb all the alpha rays, over the area of skin to be observed. The surface of the filtering layer of gutta-percha was then painted with thorium X. In no instance was there the usual erythematous response of the underlying skin or the expected therapeutic effect (as applied over a lesion of psoriasis). This experiment was repeated many times and always with the same result.

Kuznitzky, and Simons and Strauss[18] showed that the usual radiation effect of thorium X on bacteria was interfered with when a piece of paper sufficient to absorb the alpha rays was placed between the tho-

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We are grateful to Dr. Milton Friedman and to Eleanor Oshry, physicist, for their helpful suggestions in preparing parts of this paper.

TABLE I

THORIUM X DISINTEGRATION SERIES

Name	Symbol	Half-Life	Approximate Range in Tissue in Microns*	Energy of Radiation in mev.		
				Alpha	Beta	Gamma
Thorium X	$_{88}Ra^{224}$	3.64 days	43.0	5.68	—	—
Thoron	$_{86}Rn^{220}$	54.5 sec.	50.5	6.28	—	—
Thorium A	$_{84}Po^{216}$	0.158 sec.	57.5	6.77	—	—
Thorium B	$_{82}Pb^{212}$	10.6 hrs.	—	—	0.36	—
Thorium C	$_{83}Bi^{212}$	60.5 min.	48.0	6.05	2.20	?
65% → Thorium C′	$_{84}Po^{212}$	3×10^{-7} sec.	88.5	8.77	—	—
35% → Thorium C″	$_{81}Tl^{208}$	3.1 min.	—	—	1.82	2.62
Thorium D	$_{82}Pb^{208}$	Stable	—	—	—	—

* Calculated from Table 12, p. 25, of "Actions of Radiations on Living Cells," by D. E. Lea; Cambridge University Press, 1947.

rium X source and the microorganisms irradiated.

These observations suggest that the beta and gamma rays play *little* or no role in producing the biologic effects which follow the topical application of thorium X, and that it therefore must be the alpha rays which are mainly or wholly responsible for the changes which are observed.

It is, therefore, of more than theoretical interest to reason the possible means by which the short range alpha rays of thorium X and its daughters produce the tissue changes which occur as deep as 5 and 6 times the maximum distance which the most energetic alpha rays can travel in tissue (see Table 1).

Several possible mechanisms were suggested by Lomholt[6] to explain the histopathologic changes which are found in the depths of the tissue beyond the range of the thorium X alpha rays originating at the surface of the epidermis. These are:

1. That the effect was of some other kind, rather than the ionizing power of the alpha particles (perhaps an effect of the helium atom which results when the alpha particle has lost its ionizing power). Lomholt did not consider this explanation very likely.

2. That the solution of thorium X might penetrate when rubbed into the skin. While he did not completely exclude this possibility, he reasoned that the chemical identity of thorium X with radium, which belongs to the same group as barium, would cause the thorium X to be precipitated in an insoluble form by the sulfates in the skin, and therefore it was not likely to penetrate to any depth at all. Furthermore, when he noted marked skin changes following the application (active side down) of a piece of tin foil on which there were dry precipitated thorium X salts, he concluded in favor of the third possible explanation, to wit that:

3. It was the gaseous emanation, thoron, the first radioactive daughter of thorium X, which diffused into the tissue and that a liquid vehicle was not necessary for penetration. He spoke of the emanation as an "indifferent" ("inert"—authors' note) gas which would "not be precipitated by any other matter," thus permitting it to diffuse freely into the skin.

Lomholt further stated that it was impossible to distinguish between the primary, direct and destructive effects on the cells and the heterogeneous secondary influences which follow.

As a result of work done by Witten,

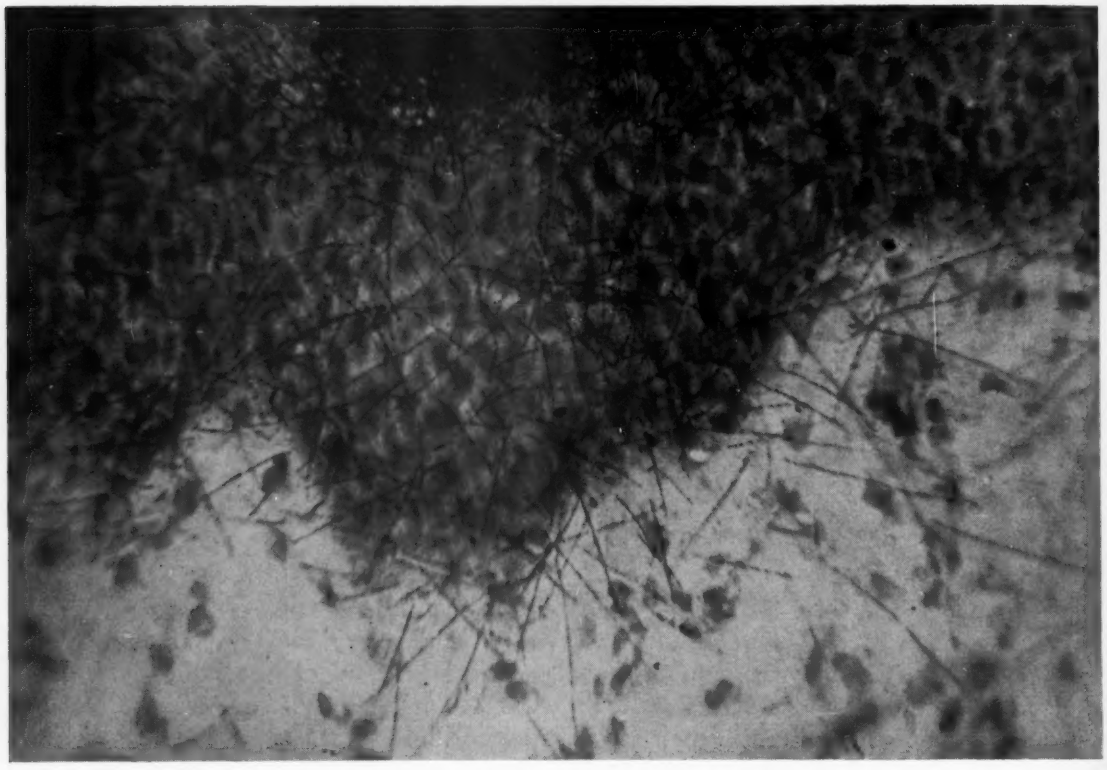

FIG. 1. A specimen of human skin biopsied two days after topical application of thorium X in lacquer The autoradiograph is prepared from a section cut perpendicular to the epidermis. The localization of thorium X and its daughters is indicated by the presence of alpha tracks in the epidermis. (610×)

Note: Histological detail is lacking because the critical focus in this and all of the photographs which follow is on the tracks in the 25 micron emulsion beneath the level of the tissue section.

Ross, Oshry, Hyman and Holmstrom,[22,23]* the routes of penetration and sites of deposition of thorium X applied to human skin in alcoholic solution, in an ointment base, and in a lacquer vehicle were demonstrated (we believe for the first time).

The technique employed by this group of investigators consisted of applying the vehicle containing the thorium X to the surface of the grossly normal skin and then covering the area with an appropriate seal, such as collodion or pliofilm.† This was allowed to remain in place two to five days, at the end of which time the covering was removed and the area anesthetized by peripheral block with novocaine. The prepared skin area was then excised and immediately transferred to the freezing microtome where the tissue was sectioned at 10–15 microns thickness. The frozen cut sections were transferred to nuclear track plates (Kodak 25 micron NTA emulsion) and exposed overnight. The following morning the exposed autoradiographs were developed, dried the necessary length of time, stained and mounted with coverglass.[24] In this form they were ready for microscopic study. The nuclear track emulsions recorded the tracks of the alpha particles and made it possible to ascertain their approximate point of origin in the tissue sections from which the autoradiographs were prepared (Fig. 1–5). Furthermore, it was possible to recognize tho-

* In 1948–1949, Witten and Otis Miller at the New York Skin and Cancer Unit, attempted to study the penetration and localization of thorium X applied to human skin. The techniques available at that time were too crude to yield entirely valid results. Shortly thereafter a project was undertaken aided by a grant from the United States Atomic Energy Commission, in which modern autoradiographic techniques were utilized in order to take advantage of the natural radioactive properties of thorium X.

† A rubber derivative (hydrochloride) resembling resins; forms a clear plastic.

rium X atoms by the presence of four-pronged stars.

It was found that when *thorium X in alcoholic solution* is applied to human skin, thorium X and its daughter products are found to:

1. Usually penetrate the epidermis down to and including the basal layer;
2. Often enter the hair follicle and penetrate the follicular wall; and
3. Occasionally enter the sweat duct and penetrate into the sweat glands.

These findings were attributed to the *alcohol vehicle itself carrying the radioactive atoms into the tissues* (Fig. 5).

This method of localizing the thorium X and its disintegration products within tissue sections was employed also for thorium X in ointment base and lacquer vehicle. It was originally anticipated that there would be some slight penetration of the ointment, but that the lacquer would hold the thorium X and it would therefore act as a radioactive thorium X "plaque."

Fig. 2. A specimen of human skin biopsied two days after topical application of thorium X in lacquer. The autoradiograph is prepared from a section cut perpendicular to the epidermis. Note the heavy accumulation of alpha tracks on the epidermal surface and within the follicle. (252×)

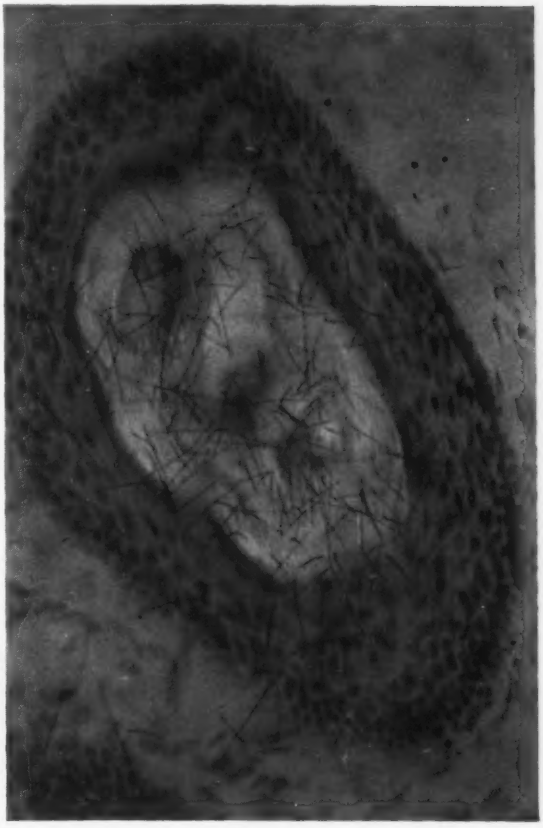

Fig. 3. A specimen of human skin biopsied three days after topical application of thorium X in ointment. The autoradiograph is prepared from a section in which the hair follicle was cut obliquely. The alpha particles are confined to the follicle and its wall. (445×)

After application to the human skin *in vivo* of thorium X in lacquer and ointment vehicles, autoradiographs showed penetration from both (Fig. 1–4). It was then learned that all thorium X preparations, *i.e.*, alcohol, ointment and lacquer, are made commercially* by dissolving the thorium X in small amounts of water, then adding this water to each of the vehicles in the required amounts to make up a preparation of given concentration. This water

* Fleischman, Burd & Company, New York.

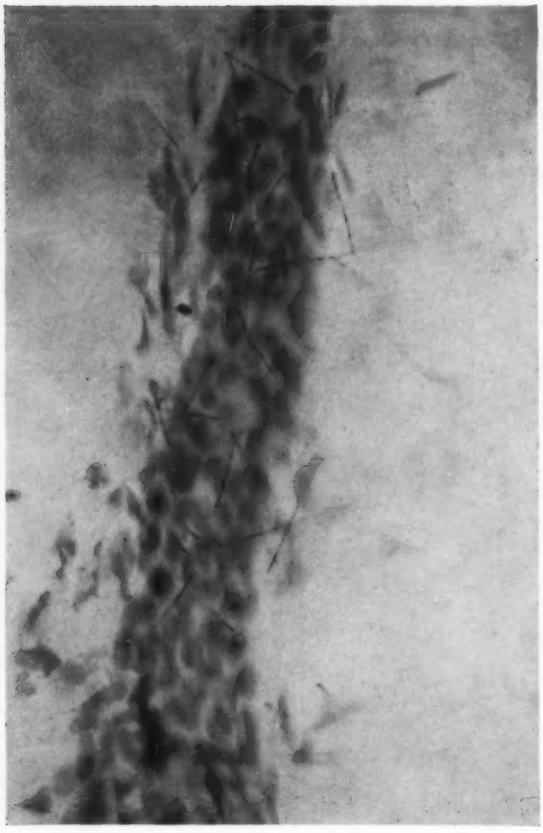

FIG. 4. A specimen of human skin biopsied two days after topical application of thorium X in ointment. The autoradiograph shows alpha tracks scattered along a sweat duct 2.4 mm. below the epidermal surface. (650×)

solution of thorium X dissolves in n-propyl alcohol, is miscible with the ointments* (though some may settle out), but is not soluble in the lacquer.† In the latter, when well shaken, the thorium X solution is merely suspended as minute droplets which settle out on standing. It was evident that the thorium X lacquer which was being used was not serving as a radioactive plaque but, quite the contrary, was in all probability serving as a vehicle from which the aqueous thorium X solution could easily separate and reach the skin surface.

With these facts in mind, consideration may now be given the various possible mechanisms by which thorium X applied to human skin may produce its biologic effects.

* A mixture of oleic acid ester and amide of diethanolamine, oleic acid and white petrolatum.

† The lacquer vehicle consists of: nitrocellulose, amyl acetate, castor oil, acetone and n-propyl alcohol. It is possible that small quantities of the water solution of thorium X or the thorium X itself might be soluble in one or more of the constituents of the lacquer.

I. ACTION FROM THE SURFACE

On theoretical grounds based on the alleged inability of the alpha rays from thorium X to penetrate even the thickness "of a thin piece of paper," it has been said that the alpha rays from this material applied to the surface of the skin could not be responsible for any biologic changes which are noted. Assuming that the thorium X or its daughters did not penetrate the tissues at all, but remained on the surface of the stratum corneum,* there are still at least the following three possible means by which this radioactive material could produce gross and histopathologic changes within the tissue:

1. *Secondary Effects.* These effects may be due to the diffusion of biologically active new chemical compounds which are formed, such as split protein products, peroxides and other oxidizing agents; or to changes in pH values; or to interference with enzyme function, etc.

2. *Direct Effects of Ionization of Alpha Rays.* The range in tissue of the most energetic of the alpha rays emitted by thorium X is calculated by be 85–90 microns. This range is sufficiently great to permit these high energy alpha particles to travel through thin epidermis and bombard the corium and vascular tissue of the papillary bodies within their reach. The histopathologic changes which are noted in the corium are most marked in the vessels and surrounding tissue within these papillary bodies. While it is a fact that the alpha particles reaching the papillary bodies would be at the end of their effective range, it is at this terminal part of the path of the alpha ray that the ionization effect is at its maximum.

3. *Direct Effect of the Beta Rays.* The

* The ability of thorium X alpha irradiation to produce erythema when acting from the surface of the skin has been demonstrated recently by the utilization of specially prepared thin-windowed plaques.[25]

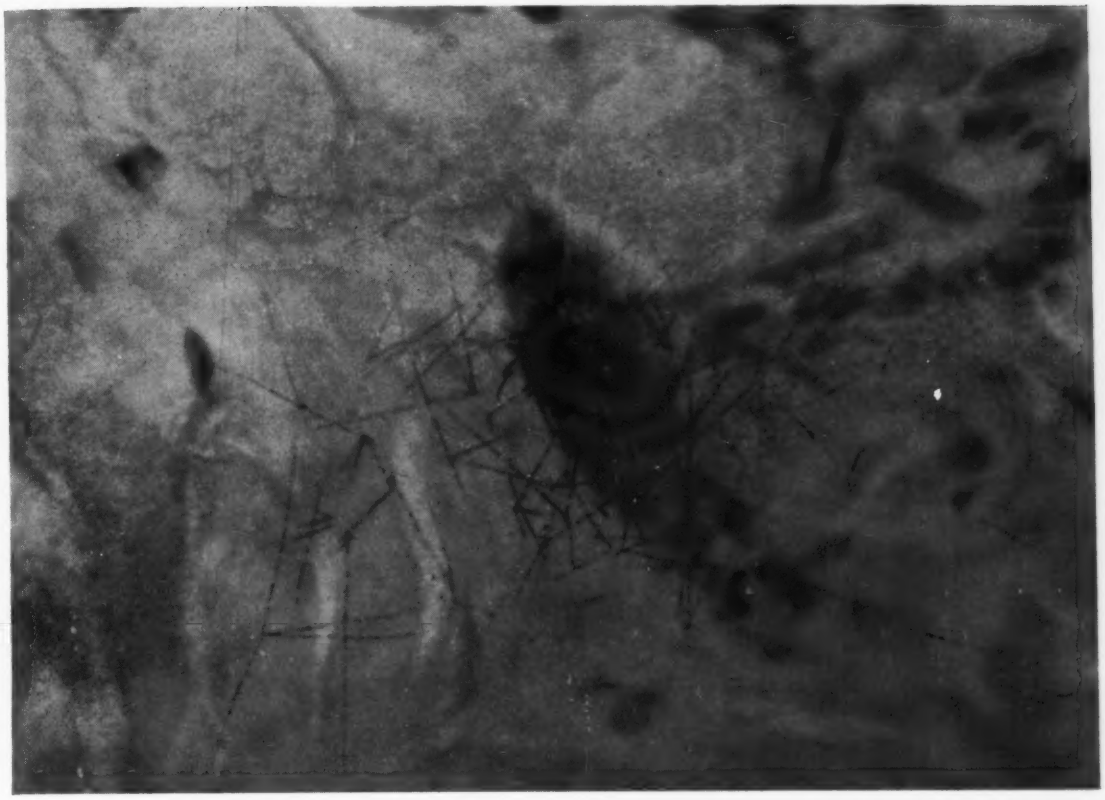

Fig. 5. A specimen of human skin biopsied five days after topical application of thorium X in alcohol. The alpha tracks produced by thorium X and its daughters are concentrated in and around a sweat duct 1.3 mm. below the epidermal surface. (910×)

possibility of the beta rays contributing to the biologic effects of thorium X has previously been considered quite remote.

However, very recent investigations by Witten, Brauer, Holmstrom and Loevinger[25] demonstrates that the beta-gamma irradiation from thorium X is capable of producing erythema and pigmentation, when acting from the surface. Nevertheless, as judged from the degree of erythema and pigmentation produced, the relative biologic effectiveness of the beta-gamma component from thorium X is many times less than that of the alpha component.

II. Action Resulting from Penetration* of the Thorium X and/or its Daughter Products

That thorium X penetrates the skin is no longer a matter of speculation, as the presence of thorium X and its disintegration products have been demonstrated in the epidermis, hair follicles, sweat ducts and sweat glands by the autoradiographic technique.[22,23] In the light of our present knowledge this penetration might conceivably take place by any one or combination of the following three ways:

1. *Diffusion of the Thoron Gas.* This method of penetration has already been discussed and none of the findings to date contradict this possibility. However, the presence of four-pronged stars, wherever there are accumulations of alpha tracks within the tissue, is definite evidence that thorium X itself penetrates. This latter finding cannot be accounted for on the basis of thoron gas diffusion* and must be explained in some other way.

* Penetration as used here refers to the penetration into and presence *within* the tissues of atoms of *thorium X and/or its disintegration products* and is to be distinguished from the penetration of an alpha particle from the surface.

* Thoron yields three alpha particles in its decay to lead, therefore it cannot produce more than a three-pronged star.

2. *Penetration of the Vehicle in Which the Thorium X Is Incorporated.* On the basis of previous reports[2,8,9,15] concerning the penetration of various vehicles into human skin, it is logical to conclude that the alcohol in which the thorium X is soluble does penetrate and carry with it atoms of thorium X as well as the radioactive daughters. It may also be *assumed* that the ointment penetrates slightly, and the lacquer not at all. Therefore, the presence of thorium X in the tissues after the surface applications of ointment and lacquer containing this radioactive material must be accounted for by some mechanism other than the thorium X being carried into the tissue by these two vehicles. The method by which thorium X is first dissolved in small quantities of water and then added to the alcohol, ointment and lacquer vehicle as prepared for clinical use in the United States has already been mentioned. It is therefore conceivable when thorium X in ointment and particularly in lacquer is applied to the skin surface the concentrated water solution of thorium X can settle from the vehicle and accumulate beneath it in direct contact with the epidermis. Once on the surface of the skin, the water solution of thorium X probably behaves in a similar fashion to the alcoholic solution of thorium X and penetrates the epidermis, hair follicles, sweat ducts and sweat glands as has been demonstrated by autoradiography.

The more remote possibility of one of the constituents of the lacquer taking the thorium X into solution and then penetrating should also be considered.*

3. *Penetration of the Radioactive Atoms Carried by Sweat and Sebaceous Materials.* The solvent action and possible carrier effect of sweat and other materials which collect under the vehicle containing the thorium X might very easily take the soluble thorium X into solution, and this solution in turn could penetrate the epidermis and its structures in a fashion similar to alcohol or water. Such a mechanism probably accounts, in part at least, for Lomholt's findings in which he noted both clinical and histopathologic changes in human skin following the application, active side down, of tin foil, on which thorium X chloride had been precipitated and dried. While Lomholt regarded these findings as supporting his theory of the diffusion into the skin of the gaseous emanation, thoron, serious consideration must be given the possibility that in these experiments the thorium X itself was taken into solution by sweat, sebum and other solvents and then carried into the epidermis and its structures.

In addition to these mechanisms by which the thorium X may be carried into the epidermis and its structures, there are certain contributing factors which may substantially enhance the penetration of the vehicle or the carrier solvent. The mechanical effect of the rubbing or massaging which is often used when applying thorium X in the various vehicles must also be considered. Here the vehicle may be propelled or aided to penetrate into the tissues or into certain of the skin structures, such as the hair follicles and sweat ducts. This effect may be still further augmented by any microscopic breaks in the skin produced by the rubbing or by the macerating effect of the covering and sealing layer, that is, by the collodion, gutta-percha, pliofilm, etc.

While the presence of thorium X and its radioactive decay products within the epidermis, hair follicles and sweat apparatus does not necessarily mean that such penetration is responsible for the biologic changes which develop, recent studies[25] strongly suggest that the greater part of the biologic effect is due to the penetration of the thorium X as contrasted to its acting solely from the surface of the skin.

If the penetration does add to the biologic effectiveness of the thorium X, it may be that the ionization effect of the small

* The lacquer vehicle consists of: nitrocellulose, amyl acetate, castor oil, acetone and n-propyl alcohol. It is possible that small quantities of the water solution of thorium X or the thorium X itself might be soluble in one or more of the constituents of the lacquer.

amounts of alpha activity found in a single hair follicle or sweat duct may not be sufficient to produce the total biologic effect in any one area, and that the changes may be the result of cross firing or summation of radiation action in many adjacent areas including the effects of the marked concentration of thorium X found both on the surface of and within the epidermis.

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PROFESSIONAL AND ADMINISTRATIVE INDEXING SYSTEM

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FOR years, the radiology residents at this and other hospitals have kept private, loose-leaf notebooks, which serve as compendia of charts, diagrams and jotted notations on cases of particular interest or teaching value. Since such notebooks are so helpful to the individual, there is every reason to believe that the condensation of these scattered data into a single, uniform indexing system might be very useful on a departmental level. To be of greatest value, of course, such an indexing system must be comprehensive, well organized and, at the same time, simple in execution. The indexing system used in the Department of Radiology in The Johns Hopkins Hospital has been developed with these factors in mind. It has brought about many improvements in both the professional and administrative spheres.

This system, a selective key to the thousands of case films and histories recorded by our department, provides us with a concise, current professional and administrative inventory; a corpus of material for teaching on post-graduate, resident and medical student levels; and a pool of radiological experience available for clinical research.

The indexing code has been established on an IBM (International Business Machine) system. This system was chosen because of the large volume of examinations. For smaller institutions, or even private offices, the index code can be adapted to a less elaborate system such as the McBee keysort, Kardex, typewritten or even handwritten filing cards. Many radiologists, who are not particularly interested in administrative data, use only the clinically pertinent codes.

Provision has been made in the neoplastic category to expand greatly the diagnostic code. This expansion allows the development of a radiation therapy code which retains the flexibility and pertinent code numbers in the diagnostic system. The radiation therapy indexing system will not be covered in this article.

A chart of the basic planning of our IBM diagnostic indexing system is as follows:

CHART OF INDEX SYSTEM

Coded Information	Use	Indexed by	IBM Columns
1. History No.	Identification	Clerk	1–7
2. Clinical Service*	Referring Clinic	Clerk	8–9
3. Age	Administrative	Clerk	10–11
4. Sex and Color	Administrative	Clerk	12
5. Examination No.	Administrative (multiple exams)	Clerk	13
6. Part Examined*	Administrative	Clerk	14–16
7. Cost of Examinaton	Administrative	Clerk	17
8. Technical Quality**	Clinical	Radiologist	18
9. Anatomical Part**	Clinical	Radiologist	19–21
10. Etiology**	Clinical	Radiologist	22–24
11. Proof or Interest**	Clinical	Radiologist	25

* See Code 1.
** See Code 2 and 3.

INDEX CODE

CODE 1

PART A

WARD OR CLINIC

01 ACCIDENT ROOM
02 ALLERGY CLINIC
03 ARTHRITIS CLINIC
04 BRADY 2
05 BRADY 3,4,5
06 BREAST CLINIC
07 BRONCHOSCOPY CLINIC
08 CANCER DETECTION CLINIC
09 CARDIAC CLINIC
10 CHEST CLINIC
11 CLUB FOOT CLINIC
12 CYSTOSCOPIC CLINIC
13 DERMATOLOGY
14 DIABETIC CLINIC
15 DIAGNOSTIC CLINIC
16* EAR, NOSE & THROAT
17 ENDOCRINE CLINIC
18 EPILEPSY CLINIC
19 EYE CLINIC
20 FOOD CLINIC
21 FRACTURE CLINIC
22 GENITO-URINARY CLINIC
23 GROUP CLINIC
24 GYNECOLOGY CLINIC
25 HALSTED 1 AND 6
26 HALSTED 2W,2S,3,4,5
27 HALSTED 7
28 HARRIET LANE (SURG. ROS.)
29* HEARING & SPEECH CLINIC
30 MARBURG 1,2,3,4
31 MEDICAL CARE CLINIC
32 MEDICAL GROUP CLINIC
33 MEDICINE 1 AND 4
34 MINOR SURGERY CLINIC
35 NEUROLOGY CLINIC
36 NEUROLOGICAL SURGERY
16* NOSE AND THROAT
37 OBSTETRICS CLINIC
38 ORTHOPEDIC CLINIC
39 ORTHOPTIC CLINIC
40 OSLER 2,3,4,6,7.
41 OSLER 5
42 OTOLOGY CLINIC
43 OUT PATIENT DEPARTMENT
44 PERSONNEL HEALTH CLINIC
45* PHIPPS PSYCHIATRIC CLINIC E1,E2,E3,W1,W2,W3
46 PHIPPS PSYCHIATRIC CLINIC E4,W4
47 PHYSICAL THERAPY
48 PLASTIC SURGERY CLINIC
49 PNEUMOTHORAX CLINIC
50 PRIVATE NOSE & THROAT
51 PRIVATE OUT PATIENT SERVICE
52 PROTEIN CLINIC
53 RADIUM CLINIC
54 RECOVERY ROOM
55 RECTAL CLINIC
56 SKIN CLINIC
29* SPEECH & HEARING CLINIC
57 STEERING CLINIC
58 SURGICAL CLINIC
59 SURGICAL DRESSING ROOM
60 THAYER 1 AND 2
61 THYROID CLINIC
62 TUMOR CLINIC
63 VASCULAR CLINIC
64 WILMER ACCIDENT ROOM
65 WILMER 2
66 WILMER 3E AND 3W
67 WOMAN'S CLINIC 42,B2,A3,B3,A5,B5
68 WOMAN'S CLINIC A4 AND B4
69 X-RAY THERAPY
99 PATHOLOGY

70 HLH 2
71 HLH 3E, 3W, 4E, 4W
72 HLH PRIVATE OUTPATIENT
73 HLH CARDIAC CLINIC
74 HLH OUTPATIENT DISPENSARY
75 HLH HEALTH CLINIC
76 HLH EPILEPSY CLINIC
77 HLH PADOCRINE CLINIC
78 HLH MEDICAL CARE CLINIC
79 HLH PREMATURE NURSERY
80 BRADY 1
81 BRADY DISPENSARY
82 WOMAN'S CLINIC 1
83 WILMER 1

CODE 1

PART B

TYPE OF EXAMINATION

SKULL

001 SKULL
002 LAMINOGRAM OF HEAD OR NECK
003 CEREBRAL ANGIOGRAM
004 ENCEPHALOGRAM
005 VENTRICULOGRAM
006 SINUSES
007 MASTOIDS
008 FACIAL BONES
009 OPTIC FORAMEN
010 MANDIBLE
012 TEETH
013 TEMPERO-MANDIBULAR JOINT
014 SIALOGRAM
015 CERVICAL SPINE
016 SPECIAL EXAMINATION OTHER THAN PARTS MENTIONED

CHEST

120 BRONCHOGRAM
121 CHEST ROUTINE
122 CHEST WITH OBLIQUES
123 CHEST WITH BARIUM SWALLOW
124 BUCKY CHEST
125 LORDOTIC CHEST
126 LAMINOGRAM CHEST
127 KYMOGRAM
128 CHEST FLUOROSCOPY
129 ANGIOCARDIOGRAM
130 RETROGRADE AMBIGRAM
131 CHEST OTHER
132 BREAST
136 RIBS
140 THORACIC SPINE

ABDOMEN G. I.

240 G. I. SERIES
243 SMALL BOWEL SERIES
245 BARIUM ENEMA
246 DOUBLE CONTRAST B. E.
248 CHOLECYSTOGRAM
249 CHOLANGIOGRAM

ABDOMEN G. U.

350 I. V. PYELOGRAM
351 RETROGRADE PYELOGRAM
353 CYSTOGRAM
354 URETHROGRAM
355 PERIRENAL AIR INSUFFLATION
357 HYSTEROSALPINGOGRAM
358 PELVIMETRY
359 PLACENTOGRAPHY

ABDOMEN OTHER

460 FLAT OR ERECT ABDOMEN
461 AORTAGRAM
462 ABDOMEN LAMINOGRAM
463 ABDOMEN OR CHEST FOR DIAPHRAGM
464 LUMBAR SPINE
465 PELVIC JOINTS
466 PELVIS
469 SACRUM AND COCCYX
470 SPLENOGRAM

UPPER EXTREMITY

570 CLAVICLE
571 SHOULDER
572 UPPER ARM
573 ELBOW
574 LOWER ARM
576 WRIST
578 HAND

LOWER EXTREMITY

680 HIP
681 FEMUR
683 KNEE
684 LOWER LEG
686 ANKLE
689 FOOT

GENERAL EXAMINATIONS

790 MYELOGRAM
791 VENOGRAM
792 ARTERIOGRAM
794 SINUS INJECTION OR FISTULA
795 FOREIGN BODY LOCALIZATION
797 THOROTRAST INJECTION
798 PATHOLOGIC SPECIMEN
799 SPECIAL PROCEDURE OTHER THAN THOSE MENTIONED
793 BONES GENERALIZED
796 DISCOGRAM

FIG. 1. This is an example of the Administrative Index Code which has been reduced in area approximately four times. The scale is in inches. The Diagnostic Index Codes have been similarly photographed on 11 by 14 inch photographic paper.

For convenience, all of the codes have been photographically reduced in size and printed on 11 by 14 inch photographic paper. Code 1, A and B, can thus be placed on one card (see Fig. 1). Similarly Code 2 has been printed on two sheets and mounted on a card. Code 3 will fit on one card.

EXPLANATION OF CHART

(1) History Number. Identification is accomplished by the use of the hospital history or unit number. The same number, always constant for an individual patient, is present on the x-ray film and on the patient's report. Six columns of the IBM card, and one extra for expansion, are assigned to the recording of history number data.

(2) The Clinical Service from which the patient is referred forms a 2 digit code. It includes sufficient entries for the recording of any of the wards or clinics in our hospital. There are 84 entries in this code (see Code 1, Part A).

(3) The Age of the Patient. This information requires 2 columns of the IBM card for its indexing.

(4) The Sex and Color of the Patient. The following code is used for indexing race and sex: number 1 for negro female, number 2 for negro male, number 3 for white female and number 4 for white male. Hence, the data relative to sex and color require only a single column on the IBM card.

(5) The Examination Number of the Patient. This column has been established in order to gather information concerning the number of patients who have had several examinations during a single visit to the department. When a patient has several examinations in one day, the number 1 is punched on the card which is prepared for the first examination; the number 2 is punched on the card which is prepared for the second examination, etc. Analysis of this type of information yields not only the number of examinations but also the number of patient visits and type of examinations conducted.

(6) A 3 digit code was developed to designate the type of examination such as skull, cerebral angiogram, cervical spine, etc. (see Code 1, Part B).

(7) The Grade or Cost of Examination.

The information for all the above entries is gleaned from the x-ray requisition and is automatically punched by the statistical clerk without any professional supervision. The remaining columns are solely concerned with the professional and medical portion of the indexing system.

(8) The Technical Quality of the Roentgenograms. The following code was developed to denote technical quality: 0—adequate; 1—excellent; 2—unsatisfactory, positioning; 3—unsatisfactory, exposure; 4—unsatisfactory, processing; 5—unsatisfactory, patient unable to cooperate; 6—unsatisfactory, preparation; 7—unsatisfactory, artefact; 8—unsatisfactory, miscellaneous.

(9) Anatomical Part. These three digits pertain to the abnormal anatomical part (see Code 2 or 3). The anatomy code is exactly the same in both alphabetical and numerical codes. It is arranged roughly in a vertical fashion starting with head, neck and chest and ending with lower extremities and generalized systems.

(10) Etiology and Morphology. The next three digits refer to the etiology and morphology of roentgenologically demonstrable disease. In Code 2 the etiology is arranged in a logical medical classification such as congenital anomalies, infection, neoplasm, and trauma. Morphology such as atelectasis, abscess, achalasia is arranged alphabetically.

Code 3 has categories identical to Code 2, but both the etiology and morphology are arranged into one single alphabetized group bearing the same code number used in Code 2.

(11) Proof or Interest. This code refers to the pathological proof and roentgenological interest: 0—tentative impression, 1—clinical or roentgenologic proof of routine pathologic interest, 2—clinical or roentgenologic proof of moderate pathologic interest, 3—clinical or roentgenologic proof of museum pathological interest, 4—biopsy or autopsy proof of routine pathologic interest, 5—biopsy or autopsy proof of moderate pathologic interest, 6—biopsy or autopsy proof of museum pathologic interest, 7—adequate clinical or pathologic proof with normal roentgenological findings.

At the end of the report of each examination the radiologist gives the typist a code number which indexes the examination for technical quality, anatomy, etiology and pathological interest. These code numbers are typed immediately under the report for the particular examination. Within limits, as many 7-number diagnostic indices as the radiologist wishes can be recorded for each examination. Only one technical index is made for each examination.

It is of paramount importance to index every examination. This applies to NORMAL (indexed x-xxx-xxx-x) examinations as well as the ABNORMAL: to SATISFACTORY examinations as well as to UNSATISFACTORY examinations or REPEAT studies. Furthermore, even though a case may have been seen many times before with the same diagnosis, *it is indexed again each time the patient appears for examination.* If the indexing code is *exactly* the same as in the previous examination of the patient, the indexing code may be given as y-yyy-yyy-y.

It is also important that the indexing of one examination be completed before the report of the next examination is begun when two or more examinations have been performed on a given patient. That is, it is

extremely important for the successful operation of the indexing code that various examinations are not allowed to run together when the reporting is done. For example, when a Gastrointestinal Series and Barium Enema are peformed, the reporting of the G. I. Series and Barium Enema must be handled separately.

At each reporting station there are photographic reproductions of the diagnostic index codes which list the indexing numbers for the various technical, anatomical, etiologic and morphologic and also interest categories (see Codes 2 and 3). In the use of the diagnostic index card, ordinarily the etiologic coding is employed in preference to the morphologic coding whenever possible. For example, it is usual to code "lung-pneumococcus-infection" rather than "lung-pneumonia" if the etiologic agent has been isolated. Furthermore, it is preferable to index a case "lung-reinfection-tuberculosis" rather than "lung-atelectasis" if the tuberculous nature of the process has been established with reasonable certainty.

Since the roentgenological method is really based on the expression of gross anatomy and pathology rather than histopathology and microbiology, there is a segment of cogent radiological opinion which emphasizes morphology rather than the presumed etiology.

There are many excellent arguments on both sides. Either the etiologic or morphologic approach may take precedence according to the needs of a particular department. Indeed a compromise solution would be to index each entity twice and include both etiology and morphology.

In order not to overload the index with inconsequential pathology, it is advisable not to index certain degenerative and minor conditions which may be within the normal range for the age group involved. The following list of conditions may be considered negative IF MINOR: (1) arteriosclerosis, (2) aortic sclerosis or elongation and tortuosity of the aorta, (3) osteoarthritis, (4) osteoporosis, (5) increased hilar markings, (6) nonspecific pulmonary fibrosis, (7) emphysema, (8) blunting of the costophrenic angles, (9) pulmonary calcifications and (10) apical pleural thickening.

Certain interesting, but minor, congenital anomalies can be lumped under the etiological entry 002. Such examples include azygos lobe of the lung, accessory lobe of the lung, bifid rib, cervical rib, prominent vascular markings of the skull.

The foregoing instructions may be clarified by several examples:

1) A negative chest film or any negative examination is indexed x-xxx-xxx-x which means:
   x—quality average
   xxx—anatomy normal
   xxx—etiology, no significant lesion
   x—interest none
2) An excellent gastrointestinal series which reveals a duodenal ulcer with crater would be indexed 1-403-850-1.
   1—excellent quality films
   403—duodenum
   850—ulcer with crater
   1—routine pathologic interest
   If the patient were re-examined at a later date and the identical film quality and abnormality were observed, the index would be y-yyy-yyy-y.
3) A chest film which is unsatisfactory due to underexposure is indexed 3-860-860.
   3—unsatisfactory exposure
   860—unsatisfcatory anatomy
   860—unsatisfactory etiology
4) A chest film in which pulmonary tuberculosis is tentatively suspected is indexed 0-104-260-0.
   0—acceptable quality
   104—lungs
   260—reinfection tuberculosis
   0—tentative impression
5) A chest film of excellent quality which shows lower lobe atelectasis is indexed 1-104-666-2.
   1—excellent quality
   104—lungs
   666—atelectasis
   2—moderate pathologic interest
   If the patient returns for a bronchogram and a mass is visualized obstructing the bronchus, the case might be indexed 0-103-320-0.
   0—acceptable quality
   103—bronchi
   320—neoplasm malignant
   0—tentative impression
   If the lesion has been proven to be carcinoma of the bronchus by biopsy, then the resident or some responsible person who reviews the surgical pathology and autopsy reports may index the case 103-320-6.

103—bronchus
320—neoplasm malignant
6—biopsy or autopsy proof of museum interest

When the typist or secretary takes the radiologist's dictation, she makes an extra carbon copy of the report. These copies, which have all the pertinent information and also code numbers assigned by the radiologist, are given each day to the statistical clerk. The statistical clerk machine-punches an IBM card for each examination. All the necessary information is gleaned from the copy of the radiological report.

At the end of each month the statistical clerk takes the cards for the preceding month and, by a process of mechanical sorting in IBM machines, prepares statistical reports for the department.

Administrative information, such as the number and type of examinations performed, the grade or cost of the examinations, total number of normal and abnormal examinations according to type and services from which the patients come, is analyzed on a monthly basis. Every three months the cards are sorted into diagnostic categories in preparation for machine tabulating. This procedure results in a compact book which includes the history numbers of all abnormal cases indexed under the various diagnostic entries.

The quarterly index book is not only a pool of radiological experiences available for clinical study and research, but furnishes the foundation for post-graduate, resident and medical student teaching.

If a student wishes to study tuberculosis, myelography or scurvy, he is referred to the quarterly index book. If a lecture is being prepared on congenital heart disease, or acute pulmonary infection, the lecturer consults the quarterly index book. If a radiologist is interested in writing a paper on pulmonary edema or collagen disease, he consults the quarterly index book. Each week a resident is required to give a seminar on departmental experience using the indexing system with such topics as duodenal ulcer, Boeck's sarcoid and mitral valvular disease. The seminars have proved valuable and are enthusiastically received.

Periodically the departmental museum file of films is evaluated, and replacements and additions are made from the accumulated index reservior. The department is also planning to use the indexing system as the basis for a 70 mm. microfilmed teaching series of films.

ADMINISTRATIVE INDEX CODE

CODE I—PART A

Ward or Clinic

01 Accident Room
02 Allergy Clinic
03 Arthritis Clinic
04 Brady 2
05 Brady 3, 4, 5
06 Breast Clinic
07 Bronchoscopy Clinic
08 Cancer Detection Clinic
09 Cardiac Clinic
10 Chest Clinic
11 Club Foot Clinic
12 Cystoscopic Clinic
13 Dermatology
14 Diabetic Clinic
15 Diagnostic Clinic
16* Ear, Nose & Throat
17 Endocrine Clinic
18 Epilepsy Clinic
19 Eye Clinic
20 Food Clinic
21 Fracture Clinic
22 Genito-urinary Clinic
23 Group Clinic
24 Gynecology Clinic
25 Halsted 1 and 6
26 Halsted 2N, 2S, 3, 4, 5
27 Halsted 7
28 Harriet Lane (Surg. Nos.)
29* Hearing & Speech Clinic
30 Marburg 1, 2, 3, 4
31 Medical Care Clinic
32 Medical Group Clinic
33 Medicine 1 and 4
34 Minor Surgery Clinic
35 Neurology Clinic
36 Neurological Surgery

16* Nose and Throat
37 Obstetrics Clinic
38 Orthopedic Clinic
39 Orthoptic Clinic
40 Osler 2, 3, 4, 6, 7
41 Osler 5
42 Otology Clinic
43 Out Patient Department
44 Personnel Health Clinic
45 Phipps Psychiatric Clinic E1, E2, E3, W1, W2, W3
46 Phipps Psychiatric Clinic E4, W4
47 Physical Therapy
48 Plastic Surgery Clinic
49 Pneumothorax Clinic
50 Private Nose & Throat
51 Private Out Patient Service
52 Protein Clinic
53 Radium Clinic
54 Recovery Room
55 Rectal Clinic
56 Skin Clinic
29* Speech & Hearing Clinic
57 Steering Clinic
58 Surgical Clinic
59 Surgical Dressing Room
60 Thayer 1 and 2
61 Thyroid Clinic
62 Tumor Clinic
63 Vascular Clinic
64 Wilmer Accident Room
65 Wilmer 2
66 Wilmer 3E and 3W
67 Woman's Clinic A2, B3, A3, B3, A5, B5
68 Woman's Clinic A4 and B4
69 X-ray Therapy
70 HLH 2
71 HLH 3E, 3W, 4E, 4W
72 HLH Private Outpatient
73 HLH Cardiac Clinic
74 HLH Outpatient Dispensary
75 HLH Health Clinic
76 HLH Epilepsy Clinic
77 HLH Endocrine Clinic
78 HLH Medical Care Clinic
79 HLH Premature Nursery
80 Brady I
81 Brady Dispensary
82 Woman's Clinic I
83 Wilmer I
99 Pathology

CODE I—PART B

Type of Examination

Skull

001 Skull
002 Tomogram of Head or Neck
003 Cerebral Angiogram
004 Encephalogram
005 Ventriculogram
006 Sinuses
007 Mastoids
008 Facial Bones
009 Optic Foramen
010 Mandible
012 Teeth
013 Temporomandibular Joint
014 Sialogram
015 Cervical Spine
016 Special Examination other than parts mentioned

Chest

120 Bronchogram
121 Chest Routine
122 Chest with Obliques
123 Chest with Barium Swallow
124 Bucky Chest
125 Lordotic Chest
126 Tomogram Chest
127 Kymogram
128 Chest Fluoroscopy
129 Angiocardiogram
130 Retrograde Angiogram
131 Chest Other
132 Breast
136 Ribs
140 Thoracic Spine

Abdomen G. I.

242 G. I. Series
243 Small Bowel Series
245 Barium Enema
246 Double Contrast B.E.
248 Cholecystogram
249 Cholangiogram

Abdomen G. U.

350 I. V. Pyelogram
351 Retrograde Pyelogram
353 Cystogram
354 Urethrogram
355 Perirenal Air Insufflation
357 Hysterosalpingogram
358 Pelvimetry
359 Placentography
360 Presacral Air Insufflation

Abdomen Other

460 Flat or Erect Abdomen
461 Aortogram
462 Abdomen Tomogram

463 Abdomen or Chest for Diaphragm
464 Lumbar Spine
465 Pelvic Joints
466 Pelvis
469 Sacrum and Coccyx
470 Splenogram

Upper Extremity

571 Shoulder
572 Upper Arm
573 Elbow
574 Lower Arm
576 Wrist
578 Hand

Lower Extremity

680 Hip
681 Femur
683 Knee
684 Lower Leg
686 Ankle
689 Foot

General Examinations

790 Myelogram
791 Venogram
792 Arteriogram
793 Bone Survey
794 Sinus Injection or Fistula
795 Foreign Body Localization
796 Discogram
797 Thorotrast Injection
798 Pathologic Specimen
799 Special Procedure other than those mentioned
800 Arthrogram

DIAGNOSTIC INDEX CODE

Numerical Listing
Code 2

Technical Quality Code

0 Adequate
1. Excellent
2. Unsatisfactory positioning
3. Unsatisfactory exposure
4. Unsatisfactory processing
5. Unsatisfactory patient unable to cooperate
6. Unsatisfactory preparation
7. Unsatisfactory artefact
8. Unsatisfactory—Miscellaneous

Anatomy

xxx Normal
yyy Identical Index Code
001 *Head and Neck*
002 Cranium
003 Brain and Meninges
004 Intracranial Vessels
005 Pituitary and Suprasellar Area
006 Sella Turcica
007 Sinuses
008 Mastoids and Ear
009 Facial Bones
010 Eye, Orbit
011 Optic Foramen
012 Mandible
013 Oral Cavity, Pharynx, Nasal Cavity
014 Teeth and Dental Structures
015 Temporomandibular Joint
016 Salivary Glands
017 Cervical Spine
018 Larynx
019 Thyroid
020 Parathyroid
308 Spinal Cord and Meninges

101 *Chest (Respiratory)*
102 Trachea
103 Bronchi
104 Lungs
105 Fissures
106 Pleura and Pleural Space
107 Hilar Nodes
108 Lymphatics
308 Spinal Cord & Meninges

201 *Chest (Cardiovasuclar)*
202 Heart
203 Pericardium
204 Aorta
205 Pulmonary Arteries
206 Vena Cava
207 Intrapulmonary Vessels
208 Other Great Vessels
209 Pulmonary Veins
210 Mitral Valve
211 Tricuspid Valve
212 Aortic Valve
213 Pulmonary Valve
214 Coronary Vessels
215 Endocardium

301 *Chest (Other)*
302 Breast

303 Clavicle
304 Esophagus
305 Mediastinum
306 Ribs
307 Scapula
308 Spinal Cord and Meninges
309 Sternum
310 Thoracic Spine
311 Thymus

401 *Abdomen (G. I.)*
402 Stomach and Pylorus
403 Duodenum
404 Small Bowel
405 Large Bowel
406 Appendix
407 Liver and Ducts
408 Gallbladder
409 Pancreas

501 *Abdomen (G.U.)*
502 Kidney
503 Perirenal Space
504 Ureter
505 Bladder
506 Urethra
507 Prostate
508 Testis, Seminal Vesicles & Other
509 Uterus and Vagina
510 Ovary and Tube
511 Placenta and Fetus

601 *Abdomen (Other)*
602 Abdominal Lymph Nodes
603 Abdominal Vessels
604 Adrenal
605 Diaphragm and Space
606 Lumbar Spine
607 Pelvic Joints
608 Pelvis
609 Peritoneum, Omentum, Mesentery
610 Retroperitoneal Space
611 Sacrum and Coccyx
612 Spleen
308 Spinal Cord and Meninges

701 *Upper Extremity*
702 Shoulder (Joint)
703 Humerus
704 Elbow (Joint)
705 Radius
706 Ulna
707 Wrist (Joint)
708 Carpal Bones
709 Metacarpal and Phalanges
710 Hand (Joints)

801 *Lower Extremity*
802 Hip (Joint)
803 Femur
804 Patella
805 Knee (Joint)
806 Tibia
807 Fibula
808 Ankle (Joint)
809 Tarsals
810 Metatarsals and Phalanges
811 Foot (Joints)

901 *Miscellaneous*
902 Peripheral Nerves
903 Peripheral Vessels
904 Bones, Generalized
905 Joints, Generalized
906 Lymph Nodes, Generalized
907 Soft Tissues, Generalized
908 Bursa
909 Tendons

Etiology

yyy Identical Index Code
xxx Normal
001 Normal Variations
002 Congenital Anomaly (ies)—Minor
003 Physiologic States
004 Pregnancy
005 Pregnancy—Multiple
006 Bone Age—Normal

010 *Congenital Anomaly (Malformation)*

General

011 Agenesis, Aplasia, Hypoplasia, Atrophy, Absence
012 Atresia, Imperforate opening
013 Bifid, Bifurcation, Septate
014 Cyst or Cysts (Congenital)
015 Diaphragm, Valve, Adhesive Band
016 Diverticulum
017 Duplication, Supernumerary, Poly
018 Ectopic, Heterotopic, Displacement, Aberrant
019 Exstrophy, Epispadias, Hypospadias
020 Fistula
021 Fusion, Synostosis
022 Herniation
023 Hyperplasia, Macro, Mega, Megalo, Enlargement
024 Hypertrophy, Dilatation
025 Malrotation
026 Meckel's Diverticulum
027 Meconium Ileus
028 Meconium Peritonitis
029 Situs Inversus (Partial)
030 Situs Inversus (Complete)
031 Stenosis

Specific

Skeletal Developmental Anomaly
040 Achondroplasia
041 Chondrodysplasia—Osteochondrodystrophy
042 Lipochondrodysplasia (Hurler's Syndrome) —Gargoylism
043 Osteochondromata Multiple

049 *Dysostosis Skull*
050 Craniosynostosis
051 Hypertelorism
052 Lacunar Skull (Lückenschädel)
053 Parietal Foramen
054 Sutures Abnormal
055 Wormian Bones

056 *Dysostosis*
057 Cleidocranial Dysostosis
058 Hemivertebra
059 Klippel-Feil Syndrome
060 Spina Bifida

062 *Bone Forming or Bone Formation (Anomaly)*
063 Calcinosis Circumscripta
064 Calcinosis Interstitialis
065 Calcinosis Universalis
066 Cutis Hyperelastica (Ehlers-Danlos)
067 Melorrheostosis
068 Osteogenesis Imperfecta
069 Osteopetrosis—(Albers-Schönberg)
070 Osteopoikilosis

074 *Deformity (Congenital)*
075 Arachnodactyly
076 Clubfoot, Calcaneo Equinovarus
077 Clubfoot, Talipes Equinovarus
078 Dislocation (Congenital)
079 Genu Recurvatum
080 Hallux Valgus
081 Hammer Toe
082 Pectus Excavatum

083 *Congenital Heart*
084 Auricular Septal Defect
085 Biloculare—Triloculare
086 Dextrocardia (see also Situs Inversus)
087 Ebstein's Syndrome
088 Eisenmenger's Syndrome
089 Lutembacher's Syndrome
090 Tetralogy of Fallot
091 Tricuspid Stenosis
092 Ventricular Septal Defect
093 Fibroelastosis

097 *Great Vessels' Anomaly*
098 Arteriovenous Aneurysm
100 Coarctation (Adult)
101 Coarctation (Infantile)
102 Coronary Aberrant
104 Patent Ductus
106 Pulmonic Stenosis
108 Transposition
110 Truncus Arteriosus
111 Vein Anomalous—Vena Cava
112 Vein Anomalous—Pulmonary

114 *Central Nervous System (Anomaly)*
115 Anencephaly
116 Cavum Septum Pellucidum, Cyst
117 Cavum Vergae, Cyst
118 Corpus Callosum, Agenesis
119 Hemangiomatosis—Lindau
120 Hydrocephaly External
121 Hydrocephaly Internal
122 Meningocele—Meningoencephalocele Meningomyelocele
123 Microencephaly
124 Porencephaly
125 Sturge-Weber Syndrome
126 Tuberous Sclerosis

131 *Growth Abnormalities*
132 Bone Age Advanced
134 Bone Age Retarded
136 Dwarfism
140 Prematurity

200 *Infection*
210 Bacteria
212 Pneumococcus
214 Streptococcus
216 Staphylococcus
220 Mycotic—Fungus
230 Parasites
235 Protozoa
238 Virus
240 Sarcoid
249 Syphilis
250 Syphilis Congenital
252 Syphilis Late
254 Tuberculosis
256 Miliary
258 Primary
260 Reinfection
263 Leprosy

300 *Neoplasm*
310 Benign
320 Malignant
330 Metastatic
330 Blood Forming Organs
340 Hodgkin's
342 Leukemia
344 Lymphosarcoma
346 Myeloma, Multiple
348 Polycythemia Vera

349 Miscellaneous Neoplasms and Questionable Neoplasms or Inflammatory Masses
- 350 Epidermoid, Cholesteatoma
- 352 Fibrous Dysplasia
- 354 Fibrous Dysplasia Polyostotic (Albright)
- 360 Hyperostosis
- 363 Mucocele
- 364 Osteoid Osteoma
- 370 Polyp—Polyposis

397 *Trauma*
398 Disc, Ruptured
399 Dislocation
400 Fracture
401 Fracture Dislocation
403 Perforated Viscus
404 Residual Changes
405 Rupture or Contusion
406 Slipped Epiphysis
407 Spondylolisthesis
408 Spondylolysis
409 Subluxation

410 *Postoperative*

415 *Chemical and Physical Agents*
416 Air Embolus—Caisson Disease
417 Bismuth
418 Fluorine
419 Foreign Body or Material Non-opaque
420 Foreign Body or Material Opaque
422 Lead
423 Phosphorus
424 X-ray, Radium, Irradiation
429 Pneumoconiosis
- 430 Silicosis
- 432 Silicotuberculosis

434 Aspiration Pneumonia—Lipoid
436 Aspiration Pneumonia
437 Lye

440 *Metabolic Disease*
441 Nutritional Disease
- 442 Osteomalacia
- 444 Rickets
- 445 Rickets and Scurvy
- 446 Scurvy
- 447 Sprue—Celiac Disease
- 448 Vitamin A Overdosage
- 449 Vitamin B Deficiency—Beriberi
- 450 Vitamin D Overdosage

455 Endocrine Dysfunction
456 Basophilism—Cushing's
457 Diabetes Mellitus
458 Hyperadrenalism
459 Hyperfunction
460 Hypergonadism
462 Hyperparathyroidism
464 Hyperpituitarism—Acromegaly
465 Hyperthyroidism
466 Hypoadrenalism—Addison's
467 Hypofunction
468 Hypogonadism
470 Hypoparathyroidism
471 Hypopituitarism—Simmonds'
472 Hypothyroidism—Cretin—Myxedema
475 Endogenous Metabolism Abnormality
- 477 Gout
- 478 Renal Rickets

480 Blood Dyscrasias
- 482 Anemia Erythroblastic—Cooley's Anemia
- 484 Anemia Sickle Cell
- 486 Hemophilia

487 Reticulosis
- 488 Eosinophilic Granuloma
- 489 Gaucher's
- 490 Hand-Schüller-Christian

491 *Degenerative Diseases*
494 Arteriosclerosis
500 Osteoarthritis—Hypertrophic Arthritis

501 *Etiology Obscure*
502 Benign Cortical Hyperostosis Caffey's
503 Cor Pulmonale
504 Cystic Fibrosis of Pancreas—Lungs
505 Hypertension
506 Leontiasis Ossea
508 Neurotrophic
510 Osteitis Deformans—Paget's
511 Pulmonary Osteoarthropathy
512 Regional Enteritis
514 Ulcerative Colitis

515 *Collagen and Alleged Collagen*
520 Rheumatoid Arthritis
522 Rheumatic Heart
525 Scleroderma—Lupus, Periarteritis

529 *Hypersensitivity*
530 Asthma
531 Erythema Nodosum
532 Loeffler's Syndrome

Morphology

Morphology, Density & Pathology Change

A

650 Abscess
652 Achalasia—Cardiospasm
654 Adhesion
656 Air
657 Air & Fluid

658 Aneurysm
660 Arnold Chiari
662 Artefact
664 Aseptic Necrosis
666 Atelectasis
668 Atelectasis—Miliary
670 Atony
672 Atrophy

B

674 Bezoar
676 Blood, Hemorrhage, Hematoma, Cephalhematoma
678 Bone Destruction
680 Bone Sclerosis—Osteoblastic, Osteogenic
682 Bronchiectasis
684 Bulla, Bleb, Pneumatocele

C

686 Calcification Abnormal—Ossification
688 Calcification Normal
690 Calculus—Non-opaque
692 Calculus—Opaque
694 Caseation
696 Cavity
698 Chalasia
700 Compression
702 Congestion
704 Curvature Abnormal, Kyphosis, Scoliosis, Lordosis
706 Cyst

D

708 Decalcification—Osteoporosis
710 Deformity
712 Deformity—Extrinsic
714 Deformity—Intramural
716 Deformity—Intrinsic
718 Density—Decreased
720 Density—Increased
722 Dilatation
724 Displacement
726 Diverticulum—Diverticulosis

E

728 Edema
730 Effusion
732 Emboli
734 Emphysema—General
736 Emphysema—Lobar or Segmental
738 Emphysema—Subcutaneous
740 Empyema
742 Epiphysitis
744 Eventration

F

746 Failure
748 Fat or Lipoid Material
749 Fetus, Abnormal
750 Fibrosis
752 Fistula
754 Fluid
657 Fluid and Air
758 Fusion—Ankylosis

G

760 Gangrene

H

762 Herniation—Prolapse
764 Hydropneumothorax
765 Hydrothorax
766 Hypertrophy (Enlargement)
767 Hydronephrosis

I

768 Ileus—Adynamic
770 Ileus—Dynamic
772 Infarct
774 Infiltration
776 Inflammation
778 Intussusception
780 Irritability, Spasm, Spastic

L

781 Length, Decreased, Shortening
782 Length, Increased, Redundancy
748 Lipoid Material or Fat
786 Loose Bodies—Osteochondromatosis
788 Lumen Change

M

789 Miliary Lesion—Non TBC
790 Miscellaneous

N

792 Non-union
794 Non-visualization

O

796 Obstruction
798 Osteochondritis
800 Osteochrondritis Dissecans
708 Osteoporosis—See Decalcification

P

802 Paralysis
804 Periostitis
806 Peristalsis—Motility Abnormal
808 Physiological Disturbance
809 Placenta, Abnormal
810 Platybasia, Basilar Impression
812 Pleurisy
813 Plummer—Vinson Syndrome
817 Pneumonia
818 Pneumoperitoneum
819 Poor Visualization or Concentration
820 Pneumothorax
821 Pregnancy Abnormal
822 Ptosis

823 Pus
824 Pyelolymphatic—Backflow
826 Pyelointerstitial—Backflow
827 Pyelotubular—Backflow
828 Pyelovenous—Backflow

R

829 Radiolucency

S

830 Sclerosis
832 Sinus Tract Demonstration
834 Stenosis
836 Stricture—Constriction
738 Subcutaneous Emphysema

T

840 Thickening—Widening
842 Thinning—Narrowing
844 Thrombosis
846 Traction

U

850 Ulcer with Crater
855 Ulcer without Crater
859 Undiagnosed
860 Unsatisfactory

V

870 Varices—Varicose
880 Volvulus

Proof and Interest Code

0 Tentative impression.
1. Clinical or roentgenologic proof of routine pathologic interest.
2. Clinical or roentgenologic proof of moderate pathologic interest.
3. Clinical or roentgenologic proof of museum pathological interest.
4. Biopsy or autopsy proof of routine pathologic interest.
5. Biopsy or autopsy proof of moderate pathologic interest.
6. Biopsy or autopsy proof of museum pathologic interest.
7. Adequate clinical or pathologic proof with normal roentgenological findings.

DIAGNOSTIC INDEX CODE

Alphabetical Listing
Code 3

Technical Quality Code

0 Adequate
1. Excellent
2. Unsatisfactory positioning
3. Unsatisfactory exposure
4. Unsatisfactory processing
5. Unsatisfactory patient unable to cooperate
6. Unsatisfactory preparation
7. Unsatisfactory artefact
8. Unsatisfactory—Miscellaneous

Anatomy

xxx Normal
yyy Identical Index Code

001 *Head and Neck*
002 Cranium
003 Brain and Meninges
004 Intracranial Vessels
005 Pituitary Suprasellar Area
006 Sella Turcica
007 Sinuses
008 Mastoids and Ear
009 Facial Bones
010 Eye, Orbit
011 Optic Foramen
012 Mandible
013 Oral Cavity, Pharynx, Nasal Cavity
014 Teeth and Dental Structures
015 Temporomandibular Joint
016 Salivary Glands
017 Cervical Spine
018 Larynx
019 Thyroid
020 Parathyroid
308 Spinal Cord and Meninges

101 *Chest (Respiratory)*
102 Trachea
103 Bronchi
104 Lungs
105 Fissures
106 Pleura and Pleural Space
107 Hilar Nodes
108 Lymphatics
308 Spinal Cord & Meninges

201 *Chest (Cardiovascular)*
202 Heart
203 Pericardium
204 Aorta
205 Pulmonary Arteries
206 Vena Cava
207 Intrapulmonary Vessels
208 Other Great Vessels
209 Pulmonary Veins
210 Mitral Valve
211 Tricuspid Valve
212 Aortic Valve
213 Pulmonary Valve
214 Coronary Vessels
215 Endocardium

301 *Chest (Other)*
302 Breast
303 Clavicle
304 Esophagus
305 Mediastinum
306 Ribs
307 Scapula
308 Spinal Cord and Meninges
309 Sternum
310 Thoracic Spine
311 Thymus

401 *Abdomen (G.I.)*
402 Stomach and Pylorus
403 Duodenum
404 Small Bowel
405 Large Bowel
406 Appendix
407 Liver and Ducts
408 Gallbladder
409 Pancreas

501 *Abdomen (G.U.)*
502 Kidney
503 Perirenal Space
504 Ureter
505 Bladder
506 Urethra
507 Prostate
508 Testis, Seminal Vesicles & Other
509 Uterus and Vagina
510 Ovary and Tube
511 Placenta and Fetus

601 *Abdomen (Other)*
602 Abdominal Lymph Nodes
603 Abdominal Vessels
604 Adrenal
605 Diaphragm and Space
606 Lumbar Spine
607 Pelvic Joints
608 Pelvis
609 Peritoneum, Omentum and Mesentery
610 Retroperitoneal Space
611 Sacrum and Coccyx
612 Spleen
308 Spinal Cord and Meninges

701 *Upper Extremity*
702 Shoulder (Joint)
703 Humerus
704 Elbow (Joint)
705 Radius
706 Ulna
707 Wrist (Joint)
708 Carpal Bones
709 Metacarpal and Phalanges
710 Hand (Joints)

801 *Lower Extremity*
802 Hip (Joint)
803 Femur
804 Patella
805 Knee (Joint)
806 Tibia
807 Fibula
808 Ankle (Joint)
809 Tarsals
810 Metatarsals and Phalanges
811 Foot (Joints)

901 *Miscellaneous*
902 Peripheral Nerves
903 Peripheral Vessels
904 Bones, Generalized
905 Joints, Generalized
906 Lymph Nodes, Generalized
907 Soft Tissues, Generalized
908 Bursa
909 Tendons

Etiology and Morphology

Alphabetical

A

018 Aberrant
650 Abscess
011 Absence
652 Achalasia
040 Achondroplasia
464 Acromegaly
466 Addison's Disease
654 Adhesion
015 Adhesive Band
132 Advanced Bone Age
011 Agenesis
656 Air
657 Air and Fluid

416 Air Embolus
069 Albers-Schönberg
354 Albright
482 Anemia—Cooley's
482 Anemia—Erythroblastic
484 Anemia Sickle Cell
115 Anencephaly
658 Aneurysm
098 Aneurysm Arteriovenous
758 Ankylosis
011 Aplasia
075 Arachnodactyly
660 Arnold-Chiari
662 Artefact
494 Arteriosclerosis
098 Arteriovenous Aneurysm
520 Arthritis—Rheumatoid
500 Arthritis—Hypertrophic or Osteo
664 Aseptic Necrosis
436 Aspiration Pneumonia
434 Aspiration Pneumonia—Lipoid
530 Asthma
666 Atelectasis
668 Atelectasis—Miliary
670 Atony
012 Atresia
672 Atrophy
011 Atrophy—Congenital
084 Auricular Septal Defect

B

210 Bacterial Infection
810 Basilar Impression
456 Basophilism
502 Benign Cortical Hyperostosis
310 Benign Neoplasm
449 Beriberi
674 Bezoar
013 Bifid
013 Bifurcation
085 Biloculare—Heart
417 Bismuth
684 Bleb
676 Blood
480 Blood Dyscrasias
339 Blood Forming Organs—Neoplasm
132 Bone Age—Advanced
006 Bone Age—Normal
134 Bone Age—Retarded
678 Bone Destruction
062 Bone Formation (Anomaly)
680 Bone Sclerosis
682 Bronchiectasis
684 Bulla

C

502 Caffey's Disease
416 Caisson Disease
076 Calcaneo Equinovarus
686 Calcification Abnormal
688 Calcification Normal
063 Calcinosis Circumscripta
064 Calcinosis Interstitialis
065 Calcinosis Universalis
690 Calculus Non-opaque
692 Calculus Opaque
652 Cardiospasm
694 Caseation
696 Cavity
116 Cavum Septum Pellucidum (Cyst)
117 Cavum Vergae (Cyst)
447 Celiac Disease
114 Central Nervous System
676 Cephalhematoma
698 Chalasia
415 Chemical and Physical Agents
350 Cholesteatoma
041 Chondrodysplasia
057 Cleidocranial Dysostosis
076 Clubfoot, Calcaneo Equinovarus
077 Clubfoot, Talipes Equinovarus
100 Coarctation Adult
101 Coarctation Infantile
514 Colitis—Ulcerative
515 Collagen Diseases
700 Compression
010 Congenital Anomaly (Malformation)
002 Congenital Anomaly—Minor
014 Congenital Cyst(s)
083 Congenital Heart (Nonspecific)
702 Congestion
836 Constriction
405 Contusion
482 Cooley's Anemia
503 Cor Pulmonale
102 Coronary Aberrant
118 Corpus Callosum—Agenesis
050 Craniosynostosis
472 Cretin
704 Curvature Abnormal
456 Cushing—Basophilism
066 Cutis Hyperelastica
706 Cyst
014 Cyst—Congenital
116 Cyst of Cavum Septum Pellucidum
117 Cyst of Cavum Vergae
504 Cystic Fibrosis of Pancreas, Lungs

D

708 Decalcification
710 Deformity
074 Deformity—Congenital
712 Deformity—Extrinsic
714 Deformity—Intramural
716 Deformity—Intrinsic
491 Degenerative Diseases
718 Density—Decreased
720 Density—Increased
678 Destruction—Bone
086 Dextrocardia

457 Diabetes Mellitus
015 Diaphragm—Congenital
722 Dilatation
024 Dilatation—Congenital
398 Disc Ruptured
399 Dislocation
078 Dislocation—Congenital
724 Displacement
018 Displacement—Congenital
727 Diverticulitis
726 Diverticulosis
726 Diverticulum
016 Diverticulum—Congenital
026 Diverticulum—Meckel's
017 Duplication
136 Dwarfism
056 Dysostosis
049 Dysostosis Skull
352 Dysplasia—Fibrous
354 Dysplasia—Fibrous—Polyostotic (Albright)

E

087 Ebstein's Heart
018 Ectopic
728 Edema
730 Effusion
066 Ehlers-Danlos Syndrome
088 Eisenmenger—Heart
732 Emboli
734 Emphysema—General
736 Emphysema—Lobar or Segmental
738 Emphysema—Subcutaneous
740 Empyema
455 Endocrine Dysfunction
475 Endogenous Metabolism—Abnormality
766 Enlargement
023 Enlargement—Congenital
512 Enteritis—Regional
488 Eosinophilic Granuloma
350 Epidermoid
406 Epiphysis—Slipped
742 Epiphysitis
019 Epispadias
531 Erythema Nodosum
501 Etiology—Obscure
744 Eventration
019 Exstrophy

F

746 Failure
748 Fat
749 Fetus, abnormal
093 Fibroelastosis
750 Fibrosis
352 Fibrous Dysplasia
354 Fibrous Dysplasia—Polyostotic (Albright)
752 Fistula
020 Fistula—Congenital
754 Fluid
657 Fluid and Air
418 Fluorine
053 Foramen Parietal
419 Foreign Body or Material—Non-opaque
420 Foreign Body or Material—Opaque
400 Fracture
401 Fracture Dislocation
220 Fungus Infection
758 Fusion
021 Fusion—Congenital

G

760 Gangrene
042 Gargoylism
489 Gaucher's
079 Genu Recurvatum
477 Gout
097 Great Vessels—Anomaly
131 Growth Abnormalities

H

080 Hallux Valgus
081 Hammer Toe
490 Hand-Schüller-Christian
083 Heart—Congenital
522 Heart—Rheumatic
119 Hemangiomatosis—Lindau
676 Hematoma
058 Hemivertebra
486 Hemophilia
676 Hemorrhage
022 Hernia—Congenital
762 Herniation
018 Heterotopic
340 Hodgkin's disease
042 Hurler's Syndrome
120 Hydrocephaly External
121 Hydrocephaly Internal
727 Hydronephrosis
764 Hydropneumothorax
765 Hydrothorax
458 Hyperadrenalism
459 Hyperfunction
460 Hypergonadism
360 Hyperostosis
502 Hyperostosis—Caffey
462 Hyperparathyroidism
464 Hyperpituitarism—Acromegaly
023 Hyperplasia—Congenital
529 Hypersensitivity
051 Hypertelorism
505 Hypertension
465 Hyperthyroidism
500 Hypertrophic Arthritis
766 Hypertrophy
024 Hypertrophy—Congenital
466 Hypoadrenalism—Addison's
467 Hypofunction
468 Hypogonadism
470 Hypoparathyroidism
471 Hypopituitarism—Simmonds'

011 Hypoplasia—Congenital
019 Hypospadias
472 Hypothyroidism—Cretin—Myxedema

I

yyy Identical Index Code
768 Ileus Adynamic
770 Ileus Dynamic
027 Ileus Meconium
012 Imperforate
772 Infarct
200 Infection
210 Infection Bacterial—General
263 Infection Leprosy
220 Infection Mycotic
230 Infection Parasitic
212 Infection Pneumococcus
235 Infection Protozoa
216 Infection Staphylococcus
214 Infection Streptococcus
249 Infection Syphilis
250 Infection Syphilis Congenital
252 Infection Syphilis Late
254 Infection Tuberculosis—General
256 Infection Tuberculosis—Miliary
258 Infection Tuberculosis—Primary
260 Infection Tuberculosis—Reinfection
238 Infection Viral
774 Infiltration
776 Inflammation
778 Intussusception
424 Irradiation
780 Irritability

K

059 Klippel-Feil Syndrome
704 Kyphosis

L

052 Lacunar Skull
422 Lead
781 Length, decreased
782 Length, increased
506 Leontiasis Ossea
263 Leprosy
342 Leukemia
119 Lindau's Disease
042 Lipochondrodysplasia
434 Lipoid—Aspiration Pneumonia
748 Lipoid Material
532 Loeffler's Syndrome
786 Loose Bodies
704 Lordosis
052 Lückenschädel
788 Lumen Change
525 Lupus Erythematosus
089 Lutembacher's—Heart
437 Lye
344 Lymphosarcoma

M

023 Macro
320 Malignant Neoplasm
025 Malrotation
349 Masses Inflammatory
026 Meckel's Diverticulum
027 Meconium Ileus
028 Meconium Peritonitis
023 Mega
023 Megalo
067 Melorrheostosis
122 Meningocele
122 Meningoencephalocele
122 Meningomyelocele
440 Metabolic Disease
330 Metastatic Neoplasm
123 Microencephaly
668 Miliary Atelectasis
789 Miliary Lesion—Non-tuberculous
002 Minor Congenital Anomaly (ies)
790 Miscellaneous
806 Motility—Abnormal
363 Mucocele
346 Multiple Myeloma
043 Multiple Osteochondromata
005 Multiple Pregnancy
220 Mycotic—Infection
346 Myeloma—Multiple
472 Myxedema

N

842 Narrowing
300 Neoplasm
310 Neoplasm Benign
320 Neoplasm Malignant
330 Neoplasm Metastatic
349 Neoplasms Miscellaneous
508 Neurotrophic
792 Non-union
794 Non-visualization
xxx Normal
001 Normal Variations
441 Nutritional Disease

O

501 Obscure Etiology—Disease
796 Obstruction
686 Ossification
510 Osteitis Deformans
500 Osteoarthritis
680 Osteoblastic
798 Osteochondritis
800 Osteochondritis Dissecans
041 Osteochondrodystrophy
043 Osteochondromata Multiple
786 Osteochondromatosis
068 Osteogenesis Imperfecta
364 Osteoid Osteoma
442 Osteomalacia

069 Osteopetrosis
070 Osteopoikilosis
708 Osteoporosis

P

510 Paget's
802 Paralysis
230 Parasitic—Infection
053 Parietal Foramen
104 Patent Ductus
082 Pectus Excavatum
403 Perforated Viscus
525 Periarteritis
804 Periostitis
806 Peristalsis—Abnormal
028 Peritonitis Meconium
423 Phosphorus
808 Physiological Disturbance
003 Physiologic States
809 Placenta, abnormal
810 Platybasia
812 Pleurisy
813 Plummer-Vinson Syndrome
684 Pneumatocele
212 Pneumococcus—Infection
429 Pneumoconiosis
817 Pneumonia
436 Pneumonia Aspiration
434 Pneumonia Aspiration—Lipoid
818 Pneumoperitoneum
820 Pneumothorax
017 Poly
348 Polycythemia Vera
370 Polyp
370 Polyposis
819 Poor Visualization or Concentration
124 Porencephaly
410 Postoperative
004 Pregnancy
821 Pregnancy Abnormal
005 Pregnancy Multiple
140 Prematurity
762 Prolapse
235 Protozoa—Infection
822 Ptosis
511 Pulmonary Osteoarthropathy
111 Pulmonary Vein Anomaly
106 Pulmonic Stenosis
823 Pus
824 Pyelolymphatic Backflow
826 Pyelointerstitial Backflow
827 Pyelotubular Backflow
828 Pyelovenous Backflow

R

829 Radiolucency
424 Radium—Irradiation
782 Redundancy
512 Regional Enteritis
478 Renal Rickets
134 Retarded Bone Age
487 Reticulosis
404 Residual Changes
522 Rheumatic Heart
520 Rheumatoid Arthritis
444 Rickets
478 Rickets—Renal
445 Rickets and Scurvy
405 Rupture or Contusion

S

240 Sarcoid
525 Scleroderma
830 Sclerosis
704 Scoliosis
446 Scurvy
445 Scurvy and Rickets
084 Septal Defect—Auricular
092 Septal Defect—Ventricular
013 Septate
116 Septum Pellucidum—Cyst of Cavum
781 Shortening
432 Silicotuberculosis
430 Silicosis
471 Simmonds' Disease
832 Sinus Tract Demonstration
030 Situs Inversus (Complete)
029 Situs Inversus (Partial)
406 Slipped Epiphysis
780 Spasm
780 Spastic
060 Spina Bifida
407 Spondylolisthesis
408 Spondylolysis
447 Sprue
834 Stenosis
031 Stenosis—Congenital
106 Stenosis—Pulmonic
091 Stenosis—Tricuspid
216 Staphylococcus—Infection
214 Streptococcus—Infection
836 Stricture
125 Sturge-Weber's
738 Subcutaneous Emphysema
409 Subluxation
017 Supernumerary
054 Sutures—Abnormal
021 Synostosis
249 Syphilis
250 Syphilis—Congenital
252 Syphilis—Late

T

077 Talipes Equinovarus
090 Tetralogy of Fallot
840 Thickening
842 Thinning
844 Thrombosis
846 Traction
108 Transposition

397 Trauma
091 Tricuspid Stenosis
085 Triloculare—Heart
110 Truncus Arteriosus
254 Tuberculosis
256 Tuberculosis—Miliary
258 Tuberculosis—Primary
260 Tuberculosis—Reinfection
126 Tuberous Sclerosis

U

850 Ulcer with Crater
855 Ulcer without Crater
514 Ulcerative Colitis
859 Undiagnosed
860 Unsatisfactory

V

015 Valve
870 Varices
870 Varicose
111 Veins, Vena Cava Anomaly
112 Veins Anomaly—Pulmonary
092 Ventricular Septal Defect
238 Virus—Infection
403 Viscus—Perforated
448 Vitamin A Overdosage
449 Vitamin B Deficiency
450 Vitamin D Overdosage
880 Volvulus

W

840 Widening
055 Wormian Bones

X

424 X-ray—Irradiation

Proof and Interest Code

0 Tentative impression.
1. Clinical or roentgenologic proof of routine pathologic interest.
2. Clinical or roentgenologic proof of moderate pathologic interest.
3. Clinical or roentgenologic proof of museum pathological interest.
4. Biopsy or autopsy proof of routine pathologic interest.
5. Biopsy or autopsy proof of moderate pathologic interest.
6. Biopsy or autopsy proof of museum pathologic interest.
7. Adequate clinical or pathologic proof with normal roentgenological findings.

SUMMARY

A roentgenological indexing system has been developed which divorces anatomy from etiology, thereby allowing great flexibility in the selection of categories by using a relatively small sized single or double page card. This system has proved its worth in clinical research and teaching. It can be abridged and simplified for smaller hospitals and even private radiological practices.

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RADIATION DOSIMETRY IN THE TREATMENT OF CARCINOMA OF THE CERVIX UTERI BY INTRAPARAMETRIAL RADIOACTIVE GOLD AND RADIUM*†

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THE vast amount of study in the last few years has done much to clarify the concepts of radiation treatment for carcinoma of the cervix uteri by the recognition that, while adequate dosage to the local lesion is obtained by almost any system of radium or transvaginal irradiation, the dose in the parametrial tissues is frequently insufficient to control the cancer in this area. Most therapists agree that some failures of treatment are due to persistence or recurrence of tumor in the pelvic lymph nodes and in the lateral parametrial regions.[2,6,11,13] An analysis of several surgical series reveals incidences of lymph node involvement ranging from 25 to 50 per cent in operable cases—Stages I and II.[6] Despite the difficulty of evaluating the effects of irradiation on metastatic nodes in the pelvis, there have been several reports indicating that radiotherapy is capable of destroying tumor cells in the regional lymph nodes.[1,12,14,19] However, because of the difficulties encountered in delivering high doses of radiation to these regions, it may be that persistence and recurrence of tumor in these areas are due to insufficient irradiation. Since a significant percentage of early cases of cervical cancer will have metastatic nodes in the pelvis, and that adequate irradiation may destroy this cancer, it becomes imperative to adequately irradiate these areas in order to improve the results.

In an attempt to deliver adequate irradiation to these areas, a series of patients with carcinoma of the cervix uteri were given intraparametrial injections of a colloidal suspension of radioactive metallic gold. The technique of injection and preliminary investigation of this study have been reported elsewhere.[15,16,20] The assumed mode of action of the injected gold is threefold:

1. Beta-ray irradiation of the volume of tissue permeated by the gold.
2. Intense irradiation of the reticuloendothelial system in which the colloid is selectively concentrated.
3. Gamma-ray irradiation of a volume of tissue extending beyond the confines of the radioactive gold.

The lymph node concentration of colloidal radioactive gold has been reported previously.[17] It is the purpose of this paper to report on the two remaining modes of action of the radioactive gold.

In order to define the distribution of radiation from Au^{198} injected intraparametrially, it was necessary to relate this distribution to the bony pelvis as an anatomical frame of reference. It was also necessary to correlate the position of the lymph node-bearing areas with respect to the same frame of reference. Although the relationship of the lymph node-bearing regions to the vascular anatomy of the pelvis has been well demonstrated, its relationship to the bony pelvis as seen in roentgenological studies has not been clearly established. The localization of lymph nodes by roentgenograms of the pelvis containing metal clips placed at the time of lymphadenectomy was found to be unsatisfactory because of the distortion of the anatomy

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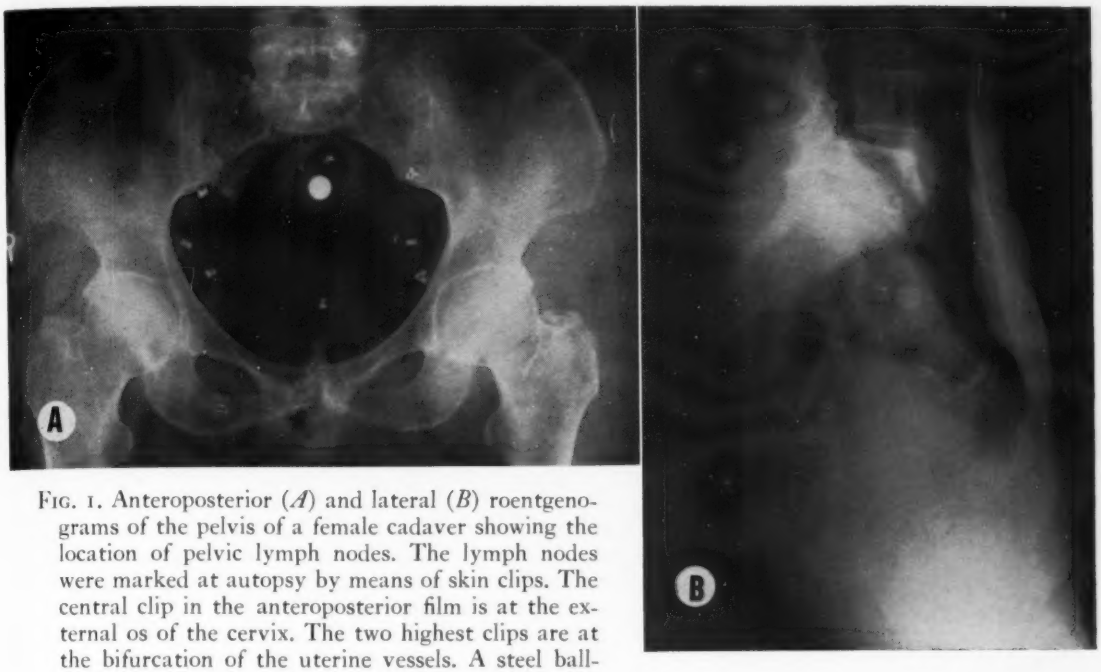

Fig. 1. Anteroposterior (*A*) and lateral (*B*) roentgenograms of the pelvis of a female cadaver showing the location of pelvic lymph nodes. The lymph nodes were marked at autopsy by means of skin clips. The central clip in the anteroposterior film is at the external os of the cervix. The two highest clips are at the bifurcation of the uterine vessels. A steel ball-bearing was placed in the uterus to determine the magnification.

consequent to the surgery. The location of lymph nodes was therefore determined more accurately in the following manner:

In 10 female cadavers, the pelvis was dissected, the specific lymph nodes were located and labeled with metal skin clips. A skin clip was placed at the external os of the cervix. Anteroposterior and lateral roentgenograms were then taken (Fig. 1).

Although the location of the lymph nodes was found to be quite variable, it was possible to confine the entire group of primary lymph nodes within a certain area, both in the anteroposterior and lateral roentgenograms. The lymph nodes selected in this study are those which have been described as most consistently involved by metastatic carcinoma from the cervix.[4,6,7,18,19] These lymph nodes formed two distinct groups. The first group lies in a fold between the external and internal iliac vessels extending from their bifuraction to the uterine artery. The second group is found alongside the obturator nerve anteriorly and laterally in its course through the pelvis. The average position of these lymph nodes in a typical female pelvis was determined by normalizing their position on the basis of the anteroposterior and lateral diameters of the true pelvis as visualized on the roentgenograms (Fig. 2).

The determination of the radiation distribution in the pelvis requires knowledge of the volume of tissue permeated by the gold as well as the rate of diffusion of the colloid in the injected tissues. This information was secured as follows:

Radioactive gold was mixed with 20 per cent diodrast and injected in the usual manner. Roentgenograms were made immediately after this procedure. This technique allowed localization of the site of injection of the gold (Fig. 3). Since diodrast is rapidly absorbed, it could not be relied upon to follow the diffusion of the colloid. Consequently, the diffusion of the radioactive colloid was traced by means of a scintiscanner type instrument which is a highly collimated scintillation counter connected to a radiation detector whose output is fed into a graphic recorder.[5,10] The counter is mounted on a frame in such a fashion as to

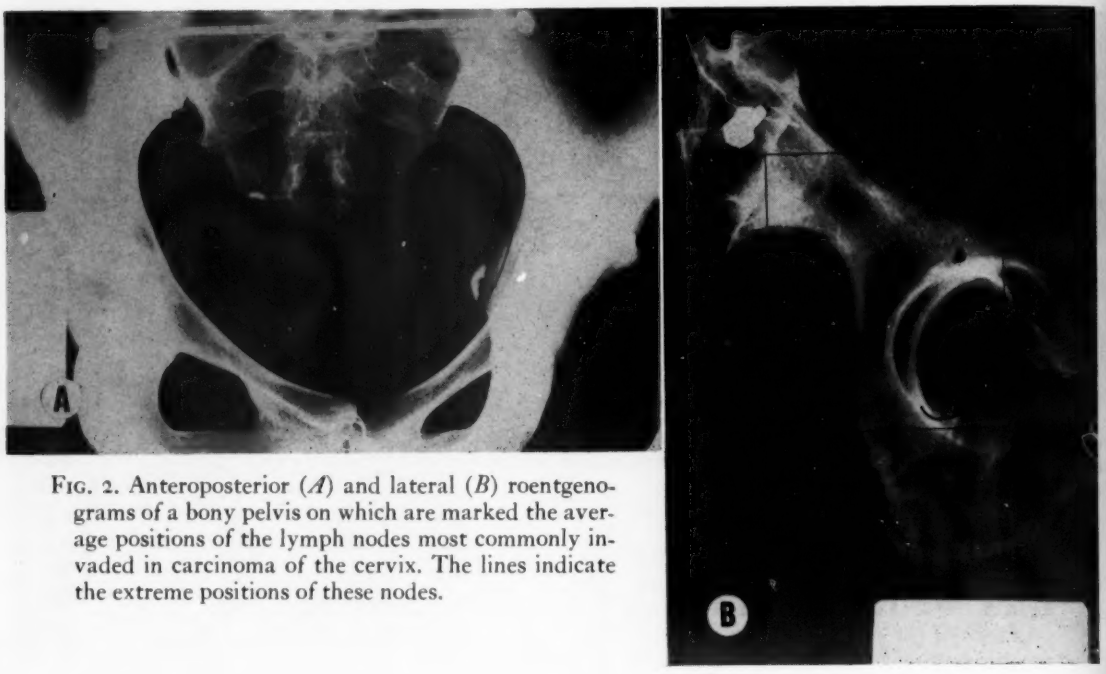

FIG. 2. Anteroposterior (*A*) and lateral (*B*) roentgenograms of a bony pelvis on which are marked the average positions of the lymph nodes most commonly invaded in carcinoma of the cervix. The lines indicate the extreme positions of these nodes.

allow the instrument to scan an area of approximately 8 by 8 inches. The motion of the counter is achieved by means of two motors whose axes are at right angles. The position of the counter, as well as the radioactivity detected, are recorded on a sheet of paper. The outline of the volume occupied by the gold, as determined by the scintiscanner, was followed for a period of two weeks after the injection. The results of this study indicated that the volume of tissue occupied by the gold a few hours after the injection does not change appreciably in the following two weeks. These results confirm some previously described animal experiments.[17] It should be noted that the study of the films showing the site of injection of the gold with diodrast, supplemented by the scintiscanner record, indicates that the lymph node-bearing volume falls well within the confines of the volume occupied by the gold.

FIG. 3. Anteroposterior roentgenogram of the pelvis of a female patient injected with radioactive gold suspended in 20 per cent diodrast. This film was taken immediately after the injection of the colloid.

The final volume occupied by the gold can be very crudely approximated by two spheres 10 cm. in diameter and centered approximately at Points B[18] of the Manchester system (Fig. 4). The volume occupied by each of these spheres is about 500 cubic centimeters. The amount of radioactive gold injected in each parametrium is 70 mc. If it is assumed that this gold is homogeneously distributed throughout the 500 cc. of tissue and if the gold decays completely within this volume, the dose of radiation contributed by the beta rays to this volume of tissue is approximately 10,600 rep. While the scintiscanner records

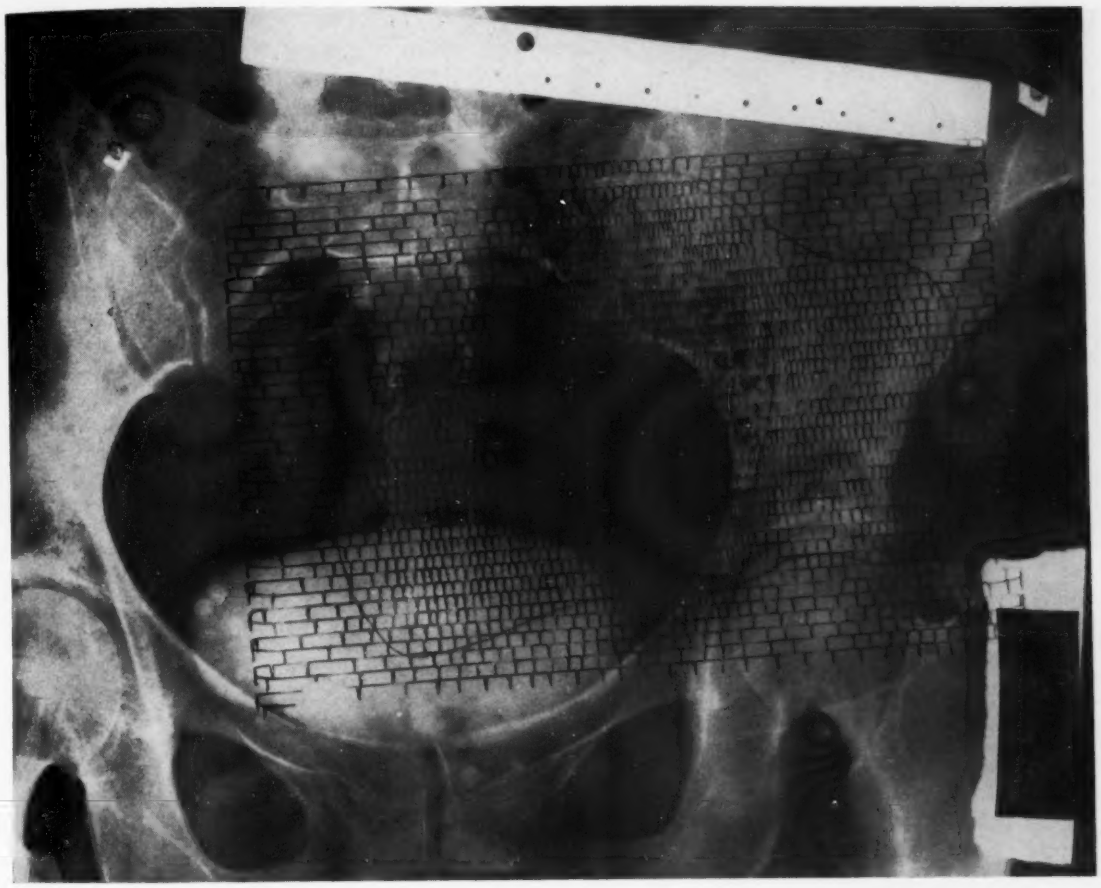

Fig. 4. Anteroposterior roentgenogram of the pelvis of a female patient injected with radioactive gold. A scintiscanner record of the extent of the gold is superimposed on the film. It should be noted that in this case only one parametrium was injected. The bladder is visualized by diodrast injected previously.

bear out the second assumption, that the gold remains localized for all practical purposes, they do not show homogeneous distribution. Because of the anatomy of the injected tissues, a completely homogeneous distribution cannot be expected to be seen on the scintiscanner records. The injected volume contains large vessels and nerves, fascial planes and muscles, as well as lymph nodes which specifically concentrate the gold. These factors must of necessity prevent a homogeneous distribution of radioactivity. The dose of 10,600 rep, therefore, is only an average value.

The gamma contribution to the total dose of radiation delivered to various points in the pelvis was measured by means of a scintillation counter probe described elsewhere.[3] The air equivalence of this instrument for the described investigation was checked and found to be satisfactory. The measurements were taken in two series of patients.

1. A series of 15 patients injected with gold and not subjected to laparotomy.
2. A series of 5 patients injected with gold and subsequently subjected to laparotomy.

In the first series the measurements were made in the bladder, the vagina and the rectum. In these measurements the highest level of activity was recorded for the bladder and rectum. In addition, the scintillation probe was directed laterally as far as possible, in an attempt to measure the dose of radiation delivered to the parametria.

FIG. 5. Anteroposterior roentgenogram of a female pelvis showing the position of the probe in the bladder at the time of measurement. This position of the probe corresponds to the "mid-parametrial" measurements listed in Table 1.

The approximate position of the probe for these measurements is shown in Figure 5.

In the second series the mid-parametrial measurements were made from above at the time of exploration. From these measurements, the total dose of radiation was computed on the basis of the following factors:

1. The average life of the gold was taken to be approximately 100 hours.
2. It was assumed that the distribution of the gold remained reasonably constant after the injection. The dosages thus determined are listed in Table 1.

It is interesting to compare the results of these measurements with the dose of gamma radiation determined by calculation alone. The dose of gamma radiation in the center of a sphere of tissue equivalent medium containing a homogeneous distribution of a radioactive isotope is given by[9]

$$\frac{4\pi CK}{\mu}(1-\exp(-\mu R))$$

where:

K is the number of roentgens at 1 cm. from 1 mc. of the isotope under consideration (for Au^{198}, $K=2.46$; ref. 9).

C is the concentration of the isotope in mc./cc.

μ is the absorption coefficient of the gamma radiation emitted in a tissue equivalent medium (for Au^{198}, $\mu=0.034^{cm.-1}$; ref. 8).

R is the radius of the sphere.

For 70 mc. of Au^{198} contained in a sphere 10 cm. in diameter this calculation gives:

20.5 r/hr.

This figure should be augmented by the contribution of the gamma radiation emitted by the gold injected in the opposite parametrium. If it is assumed that all the gold is concentrated at the homologous Point B this contribution is of the order of 1.7 r/hr., which brings the total to 22.2 r/hr. Assuming that the average life of Au^{198} is 100 hours, the dose due to gamma radiation alone at Point B should be 2,200 r, which is in good agreement with the measurements obtained in the midparametrial area (Table 1).

It should be emphasized that the intraparametrial injection of radioactive gold is primarily directed towards the irradiation of the lateral parametrium and the lymph node-bearing tissues, whereas intracavitary radium is relied upon to treat the primary lesion of the cervix. The radium application is carried out in two treatments two to fourteen days apart. Although the gold is usually injected two weeks prior to the radium applications, there is no particular indication for this time relationship. The radium is usually applied with a uterine tandem and fixed vaginal ovoids,[21] the standard radium loading being 20, 10, 5

TABLE I

Radiation Contribution	Cervix	Bladder	Rectum	Mid-parametrium
Gold-198 gamma rays (roentgens)	1,200	1,100	1,200	2,250
Radium gamma rays (roentgens)	12,000	6,000	5,000	3,350
Total gamma radiation (roentgens)	13,200	7,100	6,200	5,600
Gold-198 beta rays (rep)	0	0	0	10,600

Because of the high radiosensitivity of the bladder and rectum, the radiation doses listed for these organs represent the highest value measured by the scintillation probe. On the other hand, the cervix is relatively radiation resistant and the figure of interest is the minimum dose of radiation delivered to this structure. Consequently, the 12,000 roentgens listed in Table 1 as the radium contribution to the irradiation of the cervix represents the least irradiated point of this structure. The reason for referring to "mid-parametrium" in the fourth column rather than any specific point in the pelvis is due to the uncertainty concerning the exact location of the points where measurements were taken. This is understandable when one considers that the measurements were taken either at laparotomy or by introducing the probe into the vagina, the bladder or the rectum and directing laterally. Under such circumstances, the exact position of the tip of the probe, with respect to anatomical landmarks is relatively uncertain. However, as indicated by measurements, the distribution of gamma radiation from Au^{198} was found to be reasonably uniform in this mid-parametrial area at the level of the uterus. However, the gamma-ray dose contributed by the radium is not homogeneous throughout the parametria. The value reported in the table for this contribution was measured in the vicinity of Point B.

mg. in the tandem and 20 mg. in each ovoid. The application is given for a total of 120 hours which brings the total dose to 9,000 milligram hours. The dose of radiation delivered by the radium to strategic points in the pelvis is also shown in Table 1. These dosages were determined by scintillation counter probe measurements as previously described and in a manner similar to that used with the injection of gold in patients at the time of application of the radium.

SUMMARY

The radiation dosimetry of the combination of intraparametrial radioactive gold plus intracavitary radium, used in the treatment of carcinoma of the cervix uteri, is presented. The radiation distribution is correlated with the position of critical pelvic points involved in this form of treatment. The radiation delivered to the lateral parametrium by this form of therapy is 5,600 gamma roentgens and 10,000 to 11,000 rep.

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COMBINATION PARENTERAL AUREOMYCIN AND IRRADIATION IN FAR ADVANCED CANCER*†‡

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IN SPITE of intensive educational programs, large numbers of patients with far-advanced disease are seen in all cancer clinics. By the time these individuals appear, radical surgery frequently is either impossible or extremely mutilating and irradiation may be palliative at best. Tumor doses of radiation are limited because of the liability of the surrounding tissue to injury, with consequent complications. Because intra-arterial administration of aureomycin in large doses combined with nitrogen mustard improved operability in several patients,[4] it was decided to combine antibiotic therapy with irradiation and follow with surgery if possible in selected cases of far-advanced cancer. Since high concentrations of aureomycin inhibit cell division in tissue culture[14] as well as in small animal tumors[20] this antibiotic agent was given parenterally, preferably direct to the tumor site. All of the cases selected were those of far-advanced disease, marked local infection, large mass of tumor tissue, or poor general status.

MATERIAL

Thirty-nine patients are included in this study (Table 1). The cases were grouped according to primary site of disease. The groups were further divided as to cell type and, in the case of carcinoma of the cervix, into stage (League of Nations' Classification). Average age as well as age range for each group is indicated.

METHODS

Treatment with Irradiation. In carcinoma of the cervix, when transvaginal roentgen irradiation or radium was not used, three anterior pelvic fields and three posterior pelvic fields were employed externally. In the 2 patients treated by transvaginal roentgen irradiation and in the 4 treated with radium, two external anterior pelvic fields and two external posterior pelvic fields were used. Pressure was exerted to tolerance. Most of the patients were thin. The depth doses on the right and left sides of the pelvis were calculated in the central beam as were those for the midline field. The cones were applied without any angulation in all but one case and whatever space existed betewen the skin and cone was filled with bolus.

Intracavitary radium was used in 4 patients. Dosage from radium was expressed in gamma roentgens at Point A and Point B. The external roentgen irradiation factors in all the pelvic cases were: half-value layer, 1 mm. copper; target-skin distance, 50 cm., except for 2 cases in which the half-value layer was 3 mm. copper, target-skin distance 75 cm. The anterior and posterior fields were 8 by 10 cm., 8 by 15 cm., 10 by 15 cm. or 12 by 15 cm. in cancer of the cervix. A single posterior 10 by 15 cm. field over the sacrum for recurrence of adenocarcinoma of the corpus uteri was used in Case 1. The transvaginal factors were: half-value layer, 2.0 mm. Al; target-skin distance, 21 cm.; cone size 3–3.5 cm. except in one with half-value layer of 0.25 mm. copper.

Rectal Cases. The external factors for the rectal cases were: half-value layer, 1 mm. copper; target-skin distance, 50 cm. A single field over the appropriate area was used except in one case; in this individual, treatment was given for carcinoma of the cervical stump which was subsequently found at operation to be secondary to a rectal tumor.

Chest Cases. The external roentgen irradiation factors were: half-value layer, 1 mm. copper; target-skin distance 50 cm. Two to six

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‡ We wish to express our appreciation to Dr. Ralph M. Caulk who treated certain of the patients in this study.

TABLE I

No. of Cases	Site	Stage	No.	Cell Type	Age	
					Range	Average
25	Pelvis			23 epidermoid 1 adenocarcinoma	22–74	52
	Cervix	II	1			
		III	6			
		IV	16			
	Corpus (recurrent)		1			
4	Chest				47–67	55
	Bronchus		2	oat cell		
	Mediastinum		1	epidermoid in dermoid cyst		
	Esophagus		1	epidermoid		
4	Large intestine		3	adenocarcinoma	35–61	52
	(recurrent to neck)		1			
6	Head and neck			epidermoid	53–73	61
	Tongue		2			
	Buccal mucosa		2			
	Hypopharynx		1			
	Maxillary sinus		1			

Site and cell type of carcinoma in 39 patients who were treated by a combination of parenterally administered aureomycin and irradiation.

treatment fields were used to include areas of the primary lesion as well as areas of metastatic disease.

Head and Neck Cases. The external roentgen irradiation factors in 2 patients were: half-value layer, 3 mm. copper; target-skin distance, 75 cm., and in the others half-value layer, 1 mm. copper; target skin distance, 50 cm. Each patient was treated through two fields directed at the lesion.

Treatment time was unavoidably prolonged in some cases for various reasons, which included adverse reaction to radiation and/or antibiotic and technical difficulties.

Treatment with Aureomycin. Aureomycin hydrochloride* buffered with sodium glycinate was the antibiotic used in this series of patients. In order to obtain the highest possible tissue concentration of antibiotic, regional intra-arterial administration was employed whenever possible. In all patients with abdominal or pelvic carcinoma the abdominal aorta was cannulized according to the method developed by Klopp *et al.*[13] Because serial aureomycin blood levels have shown that, after an initial high peak, antibiotic concentration remains at an appreciably high level for approximately twelve hours,[1] the drug was administered twice daily to hospitalized patients and once daily to those seen in the Out-Patient Department. In 2 patients the intra-arterial cannulas slipped out and subsequently the drug was given intravenously. All patients with chest, head and neck disease were given aureomycin intravenously. An indwelling polyethylene cannula was used in 4 patients and multiple venipuncture was used in the others.

The aureomycin was dissolved in sterile distilled water and given in doses of 0.25 to 1 gm. twice daily. Total dose ranged from 1.5 to 42 gm. (average 18.8 gm.). Lower doses were used in the presence of hydronephrosis and poorly or nonfunctioning kidneys as demonstrated by abnormal intravenous urographic findings or by abnormally high serum nonprotein nitrogen levels. Dose was reduced in the presence of a sharp rise in serum nonprotein nitrogen or unusual nausea. Subsequent to withdrawal of the arterial cannula a pressure dressing was applied for twenty-four hours and the patient was kept in bed.

RESULTS

Table II summarizes the number in each group in which clinical improvements were noted, as well as the number on whom

* Supplied through the courtesy of Lederle Laboratories, Division of the American Cyanamid Co.

TABLE II

RESULTS OF THERAPY

Location	No.	Clinical Improvement	No Change	Surgery					
				Disease Removed	Palliative Procedure	Exploratory, No Disease Removed	Pending	Inoperable or Refused Surgery	Died Prior to Surgery
Pelvis	25	21	4	11*	2	2	3	6	1
Bowel	4	4	0	2*	0	0	1	1	0
Chest	4	2	2	0	0	1	0	2	1
Head and neck	6	5	1	2*	0	0	1	3	0
Total	39	32	7	15	2	3	5	12	2

* Surgery preceded irradiation and aureomycin administration in 1 case.

Results of combination therapy with aureomycin and irradiation in 39 cases of far-advanced carcinoma. There was some degree of improvement in 32 patients, 15 of whom had surgical removal of disease following therapy.

surgery was undertaken. Clinical improvement included:

	Cases
Regression in palpable disease	22
Cessation of gross bleeding	7
Decrease in local edema	1
Healing of ulceration	12
Increased mobility of lesion	10
Disappearance of fever	2
Necrosis of superficial nodules	1
Disappearance of dysphagia	2
Decrease in dyspnea	1
Disappearance of foul odor of oral lesion	1
Decrease in exophthalmos	1
Decrease in pain	1

Microscopic examination of surgical specimens (Table III) revealed no evidence of cancer in 4 cases, local cancer in 5 and local and lymph node disease in 6 cases.

TABLE III

MICROSCOPIC PATHOLOGY OF SURGICAL SPECIMEN

Location	No Carcinoma	Local Carcinoma	Local and Lymph Node Carcinoma
Pelvis	3	4	4
Bowel	1	1	0
Head and neck	0	0	2

Microscopic pathologic observations in 15 patients who were operated upon following combination parenteral aureomycin and radiation therapy.

Survival time from the onset of treatment is given in Table IV. One patient with Stage II, 4 with Stage III and 1 with Stage IV carcinoma of the cervix are alive and well with no evidence of disease from four to nineteen months, respectively. Residual disease is demonstrable in 8 patients with Stage III and IV carcinoma of the cervix at two to eighteen months; 2 of these are awaiting surgery. Ten patients with Stage IV disease died from two to twelve months (average 5.5 months) following institution of therapy. The single patient with carcinoma of the fundus died from complications at 0.7 month; the 4 patients with chest disease died from one to six months following the institution of treatment. Two patients with intestinal disease are alive with no evidence of disease at nine and eleven months; 1 is awaiting surgery. One patient with extensive carcinoma of the tongue is in excellent condition with no evidence of disease twelve months following combined irradiation and aureomycin. Four patients in the head and neck group lived only 0.2 to 9 months; 1 with residual disease is awaiting surgery and 1 is alive with no evidence of disease at twelve months.

TABLE IV

SURVIVAL IN MONTHS

Site	No.	Deceased	Residual Disease	No Evidence of Disease
Cervix				
Stage II	1			4
Stage III	6		14, 4*	19, 9, 19, 7
Stage IV	17	3, 11, 10, 12, 3, 3, 6, 3½, 2, 2	18, 11, 10, 5, 3, 2†	10
Fundus	1	¾		
Chest	4	6, 2, 1, 2½		
Bowel	4	3	1*	9, 11
Head and neck	6	2½‡, ¼, 9, 8	2	12

* Awaiting surgery.
† Under treatment.
‡ Died postoperatively.

Follow-up on 39 patients included in this study. Following institution of therapy, 20 lived from ¾ to 12 months, 10 were alive with residual disease at 1 to 18 months and 9 showed no gross evidence of disease at 4 to 12 months.

Complications of therapy are listed in Table V. The regularity of azotemia was attributed to the large doses of aureomycin, prolonged administration of antibiotic and frequent diminished renal reserve. Reduction of dose was always accompanied by fall in serum nonprotein nitrogen. The highest level (108 mg. per cent) occurred in Case 34, a man of very small stature who had received 19 gm. of aureomycin intravenously in eight days. Reduction, then discontinuance of therapy was followed by prompt return to a normal level.

DISCUSSION

In 1948 Munnell and Brunschwig[19] summarized the results of roentgen and radium therapy in 1,070 patients treated for primary carcinoma of the cervix at Memorial Hospital, New York, from 1934 to 1941. No Stage IV patient was cured; the average relative cure rate in Stage III disease was 17.4 per cent. An attempt to improve these results by insertion of gold-filtered radon needles through the vaginal vault was found to be conducive to formation of rectal and bladder fistulas and the production of extensive local necrosis, hemorrhage and pain.[23] When intravaginal cone therapy was substituted for radium there was a 7 per cent three year cure in Stage III and no cure in Stage IV (disease with actual invasion of the bladder or rectal mucosa by tumor or with metastases outside of the

TABLE V

SIDE EFFECTS ASSOCIATED WITH COMBINATION ANTIBIOTIC AND RADIATION THERAPY

Gastrointestinal	No.	Systemic	No.	Local	No.
Black tongue	1	Lethargy	4	Local pain (arterial injection)	8
Anorexia	6	Confusion	1	Local pain (venous injection)	5
Nausea	7	Transient fever and/or	3	Infection at cannula site	4
Vomiting	8	Transient chills	3	Chemical necrosis at cannula site	2
Abdominal cramps	1	Transient azotemia	22	Thrombosis	2
Loose stools	3	(NPN over 50 mg.%)			
Diarrhea	4				
Jaundice	5				

pelvis).[23] In a review of 192 patients with carcinoma of the cervix treated by various combinations of transvaginal, external roentgen and radium therapy, Caulk[5] includes Stage IV cases; the average survival of those followed in the latter group was nine months for 4 cases. There were no five year survivals. Only 1 of 16 patients having Stage IV carcinoma of the cervix was reported cured with roentgen and radium therapy by McKelvey and co-workers.[15] Waterman and Reid[24] improved the five year survival rate but increased complications in Stage IV carcinoma of the cervix treated with roentgen irradiation plus long radium element needles. Since Meigs[16,17,18] believes that deep pelvic lymph nodes cannot be sterilized by irradiation, he has long recommended radical surgery for carcinoma of the cervix.

Complications of radiation therapy alone include bowel reactions, rectovaginal fistulas, vesicovaginal fistulas, local necrosis and vaginal atresia.[5] Henriksen[11] observed that most vaginal fistulas result from malignant extension rather than radionecrosis since the incidence was 20.1 per cent in 154 nontreated patients with cancer of the cervix as compared with 18.8 per cent in 202 of the treated group.

There is general agreement that present-day therapy in far-advanced cancer is usually inadequate. Even when the disease is still localized yet advanced, serious deformity is often produced by the surgery or the irradiation necessary to control the cancer. The only hope of minimizing these complications is to increase the sensitivity of the tumor to the effects of irradiation without at the same time increasing the sensitivity of the surrounding structures.

The response of tissue to irradiation follows the law of Bergonié and Tribondeau, that is: the more embryonal and undifferentiated the tumor cell, the greater is the tumor's radiosensitivity. Furthermore, the destruction of hyperchromatic cells is effected more easily than that of hypochromatic cells, and dividing cells are more susceptible to radiation than cells at rest. Other factors which affect the radiosensitivity of tissue are infection, vascularity of the tumor and the general condition of the patient. Infected tissue and poorly vascularized tumors are less sensitive to irradiation. Patients in a debilitated state, from whatever cause, tolerate the general effects of irradiation poorly. A drug such as aureomycin which may suppress cell division would be expected to decrease the radiosensitivity of the tumor. However, if the metabolism of the cell is accelerated and infection is decreased these two factors might counterbalance the effect of depression of cell division and make the tumor more radiosensitive.

It has been reported that penicillin, chloromycetin and aureomycin interfere with cell division in tissue culture,[6,14] especially at high concentrations.[3,7]

Sokoloff and Eddy[20] and Trams and Klopp[22] observed regression in animal transplanted tumors which seemed to be related to amount of antibiotic administered. Gummel and Lührs[10] reported a significant growth-proliferating action of penicillin, streptomycin, chloromycetin, aureomycin and terramycin on the Jensen sarcoma of the rat; however, they administered the broad spectrum antibiotics orally.

Speck and co-workers[21] studied the effect of total body irradiation on antimicrobial defense mechanisms of mice by observing rate of death and rate of spread of infection following intramuscular injection of streptococci. In irradiated animals the streptococci disseminated more rapidly and the animals succumbed three to four days earlier than the controls. Cultures indicated that both lymphatic blockage and the filtering action of spleen and liver were virtually ineffective after irradiation. Penicillin eliminated bacteria except at the local site of infection and reduced mortality to the level of noninfected irradiated mice.

Total mortality in dogs receiving 450 r whole body irradiation was 58 per cent; mortality was reduced to 44 per cent in irradiated dogs treated with aureomycin (100 mg./kg. daily by mouth in divided

doses). The first death in the control group occurred seven days before the first death in the treated group.[8] Terramycin was shown to have a similar effect.[12] When 575 r whole body irradiation was given to dogs, neither blood transfusions nor oral aureomycin administration produced a statistically significant difference in mortality.[9]

The effective dose level of antibiotic achieved may explain the difference in results obtained in different studies. Parenteral therapy and especially intravenous administration will produce blood levels many times higher than those obtained after oral therapy. In humans at least, serum level of antibiotic appears to be related not only to dose and route of administration but also to rapidity of excretion, which in turn is largely controlled by renal function.[1,2]

It is possible that only in tissue culture can sufficient antibiotic concentration be obtained to suppress cell division. It may be that effects noted in animal tumors and human tumors are the result of suppression of secondary infection. It is certainly valid to assume that a poorly vascularized tumor will receive a much smaller concentration of drug than a tumor rich in blood vessels in spite of regional administration.

It is true that these statistics on combined irradiation and antibiotic therapy are not too impressive as yet but it is noteworthy that the tumor dosages delivered in most cases were less than the amount considered necessary to produce a favorable response clinically, yet in 3 cases no residual cancer was found at surgery. This observation coincided with the clinical impression that the sensitivity of the tumor to irradiation had been increased. It must be emphasized that the majority of these cases were such that under ordinary circumstances irradiation would not have been attempted even as a palliative measure.

The indications that such combination therapy increases sensitivity of tumor cells to irradiation lead us to believe that such treatment possibilities merit further investigation. In this study 66 per cent of the patients with Stage IV carcinoma of the cervix are still free of disease. Temporary benefits have been attained in some cases and life has been prolonged in others who were considered, when first seen, to be completely hopeless. This salvage rate, although small, seems justification for continued trials of such a regimen.

SUMMARY

1. The 39 patients with far-advanced cancer in this study included: 25 with carcinoma of the cervix uteri, 1 of the fundus, 2 of bronchogenic carcinoma, 1 of epidermoid carcinoma in a mediastinal cyst, 1 of carcinoma of the esophagus, 4 of carcinoma of the large intestine, 2 of carcinoma of the tongue, 1 of carcinoma of the buccal mucosa, 1 of carcinoma of the hypopharynx and 1 of carcinoma of the maxillary sinus.

2. Thirty-five patients received concomitant irradiation and parenteral aureomycin therapy; in 4 cases antibiotic administration preceded irradiation. Surgical removal of tumor followed in 15 cases, palliative procedures were done in 2 cases, exploration and closure were done in 3 cases and 5 patients are awaiting surgery.

3. Clinical improvement was noted in 21 pelvic, 4 bowel, 2 chest and 5 head and neck cases. Therapy produced no change in 7 cases.

4. It is too early for final evaluation of results but a number of the patients included in this study who would have been considered too hopeless for any form of therapy received temporary palliation and 9 have no evidence of disease four to nineteen months after treatment was started.

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REDUCTION OF LIFE SPAN OF RATS BY ROENTGEN IRRADIATION*†

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THIS report describes two experiments which were performed in sequence during the last five years. They are concerned with the relation between roentgen-ray dosage and average life span shortening, and are designed to answer the specific question, "Is the average reduction in survival directly proportional to the total roentgen-ray dose regardless of the dose size?" Apart from its inherent interest, the answer to this question, if applicable to man as well, has a bearing on the predicted long term effects of human exposure to roentgen or gamma irradiation in its various intensity time-duration patterns. The experimental investigation of this relationship in mammalian species involves the use of relatively large numbers of animals and a minimum observation period of several years. Consequently, despite the large number of published experiments exploring the effects of roentgen radiation on animals, information on this point is indeed sparse. Experiments have been reported[1,2,3,4,6,7] citing survival of mice and rats under duration-of-life exposure to daily doses of roentgen or gamma irradiation. In general, the results show decreases in median survival times, which appear to be approximately proportional to the median accumulated doses in the dose range of approximately 1 to 10 roentgens per day. Since in this type of experiment the accumulated dose for the animals in a single experimental group varies widely because it depends on the individual animal survival, and since with high dose rates the animal may be virtually dead some days or weeks prior to actual death, the information gained cannot be used in any direct manner to establish the quantitative relation between dose size and average life span reduction.

Lorenz *et al.*,[5] using roentgen rays, and Henshaw *et al.*,[3] using gamma rays administered to mice in a single sublethal dose, have obtained decreases in average survival (see Table 1) in substantial agreement with the results of the first of the two experiments reported below. Taken in conjunction the results of these three experiments suggest, but do not prove, that over the single dose range from 150 r up to approximately 700 r (the dose which kills half the animals in 30 days) the survivors suffer irreparable damage, expressing itself in an average reduction of life span linearly related to the dose. The above generalization has the consequence that if life shortening injury is related to the dose by a single proportionality constant for all dose sizes, and if this injury is indeed irreparable, it would follow that the reduction in life span was an effect with no threshold, depending on the total dose irrespective of the time duration of its administration. The second experiment, designed to test this proposal, demonstrates that the average reduction in life span of a rat group receiving 600 r as a single dose, is greater than that of groups receiving either 10 doses of 60 r each, or 30 doses of 20 r each given on consecutive days. The above finding, contrary to the hypothesis, places limitations on the interpretation of hitherto available data.

The roentgen-ray generator used in both experiments was a 250 kv. (peak) Picker industrial unit. The beam was filtered externally with an aluminum parabolic filter 14.2 mm. thick at the center plus a 0.5 mm. copper sheet affording a half-value layer of 2.15 mm. copper. The treatment rate was 18.5 r per minute, in air, measured at the roentgen-ray target to animal distance

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TABLE I

THE EFFECT OF ROENTGEN AND GAMMA IRRADIATION ON SURVIVAL

Reference	Animals				Dose (r)	Survival after Irradiation (wk.)	Per Cent Reduction of Life Span	Per Cent Reduction per 1,000 r	Remarks
	Kind	Age (wk.)	Sex	Number					
Present Exp. I	Wistar rats	22	Male	23	0	96.6	—	—	*Roentgen Irradiation*
				24	150	88.7	6.7	45	Males housed in separate quarters with different caretakers
				23	300	81.7	12.6	42	
				22	600	61.7	29.4	49	
		22	Female	24	0	78.7	—	—	
				23	150	75.4	4.2	28	
				24	300	71.7	8.9	30	No air-conditioning
				16	600	59.9	23.8	40	
Present Exp. II	Wistar strain local colony	31–33	Males	50	0	57.9	—	—	*Roentgen Irradiation*
				45	600	40.7	19.0	32	Air-conditioned quarters
				48	10×60	52.6	5.8	9.7	
				50	30×20	59.9	—	—	
Lorenz *et al.*[5]	C_3Hb mice	(10)	Males and females	195	0	89.1	—	—	*Roentgen Irradiation*
				154	400*	74.5	14.8	37	
				131	400†	77.1	12.1	30	
				145	900†	64.3	25.0	36	
Henshaw *et al.*[3]	CF-1 mice	(8–10)	Males and females	(100–125)	0	63.0	—	—	*Gamma Irradiation*
				(100–125)	500	56.0	9.7	19	
				(100–125)	700	39.0	33.3	47	

Animal "age" means age at time of irradiation. Survival in present experiments is mean survival. In the latter two experiments median survival is entered as estimated from published graphs. Tabular data enclosed in parentheses are inferred from general description of experimental method, although not specifically stated for this particular experiment.

* Sham operated.

† Spleen shielded.

of 25 inches. The rate was determined by trial runs made with a Victoreen 25 r chamber placed in an exposure cage sector at rat level. The exposure cage was a wheel with peripheral sector compartments individually housing 16 rats.

I. THE EFFECT OF SINGLE ROENTGEN-RAY DOSES OF 150, 300 AND 600 ROENTGENS

Experimental Procedure. A total of 96 male and 96 female Wistar albino rats (5 months old) was divided into groups of 24 rats each. One of the four groups was designated as control, the other three groups received respectively 150, 300, and 600 r single doses. A log was kept of rat deaths until all had succumbed. Rat colony space limitations required that the male and the female series be housed in different quarters (without air-conditioning) and be cared for by a different animal attendant. For this reason cross comparisons are of questionable validity.

Results. The mean survival time for each group is plotted against radiation dose in Figure 1. In calculating the mean survival times for the 600 r male and female groups, rats dying within the sixty day period after irradiation were excluded, reducing the female 600 r group to 16 rats and the male 600 r group to 23 rats. The mean survival times decreases roughly in proportion to

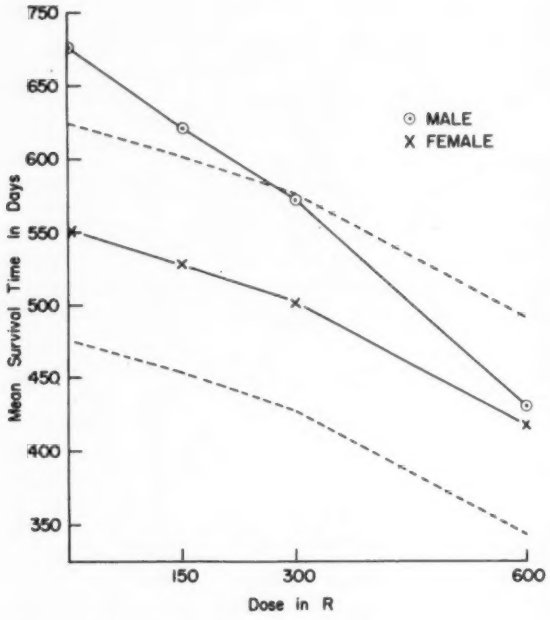

FIG. 1. The effect of single doses of roentgen radiation on mean survival times of male and female rats. Each point represents the average survival of 24 rats. The dotted lines define the 95 per cent confidence limits for the female rat series (X). Limits of equal extent apply to the curve for the male rat series but have been omitted to avoid clutter.

the dose. Since the standard deviation of the mean survival times showed only small unsystematic variations from group to group, it seemed reasonable to assign a single standard deviation (average of eight individual calculations) to the data. The 95 per cent confidence limits shown for the female rat data as dotted lines in Figure 1 are drawn on the basis of a single average standard deviation. Similar limits (two times the average standard deviation)exist for the data in the male series, but the lines have been omitted in Figure 1 to avoid confusion. The experimental validity of the proportional relationship at the 150 r point depends on the trend of the other data since statistical analysis showed that there existed one chance in three that the average survival time of the 150 r male and female groups showed no real difference from that of their respective control groups.

II. THE EFFECT OF 600 ROENTGENS ON SURVIVAL WHEN ADMINISTERED AS A SINGLE DOSE AS COMPARED WITH DIVIDED DOSES

Experimental Method. Two hundred male albino rats, aged thirty-one to thirty-three weeks, were divided at random into 4 experimental groups. The rats were of Wistar strain, bred in the local rat colony, and ranging in weight from 356 to 363 grams. The rats in Group 1, designated as controls, were sham irradiated for a time duration equal to the exposure time for Group II. Groups II, III, and IV received respectively 600 r, 60 r, and 20 r. Group III received 60 r daily on each of the following nine days, and Group IV received 20 r daily for the following twenty-nine days. Each of the irradiated groups received a total of 600 r.

The rats were kept 2 rats to a cage in air conditioned quarters. Deaths were recorded until all rats had died.

Results. The survival data are presented in Figure 2 and Table 1. The principal result of this experiment can be stated without qualification, *viz.*, the average shortening of life caused by a single dose of 600 r is marked, whereas the life span of rats receiving a dose of 20 r per day for thirty days cannot be differentiated from that of the unirradiated controls. The data suggest that the effect of 60 r repeated 10 times is intermediate between the effect of the other two dosages.

It will be noted that a larger number of deaths occurred in each group during the 380th to 390th day after irradiation (Fig. 2). This period coincided with the duration of an epidemic of pneumonia in the rat colony. It may be calculated from the data in Figure 2 that the per cent of the survivors on the 380th day which died during the interval show no significant difference from group to group. From this circumstance plus the results of gross pathological examination it is believed that all, or nearly all, of the rats dying during this interval died from the infection and not

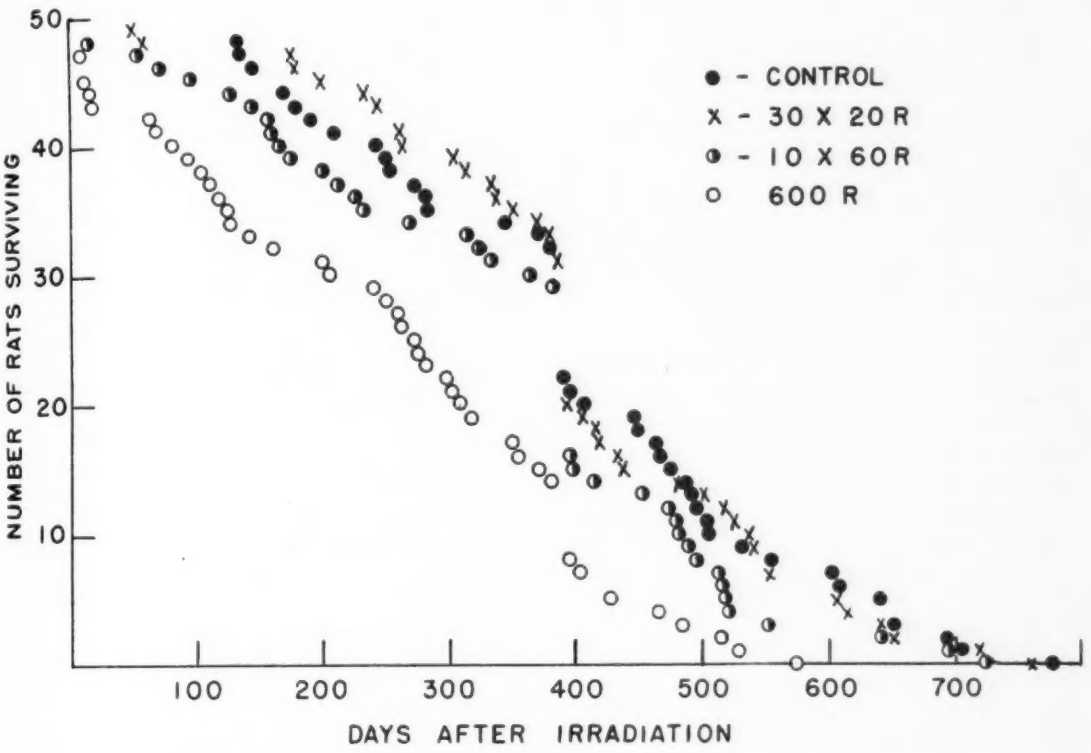

FIG. 2. Survival curves comparing a single dose of 600 r with divided doses totaling 600 r.

from the combined effects of radiation damage and aging.

The occurrence of the infection complicates the calculation of per cent of life shortening. The use of *median* survival times is obviously an inadequate representation of the data. It is equally unjustifiable to "subtract" the rats dying from infection from their experimental groups since by virtue of their survival up to that point they have established themselves as a special group with potential survival equal to or greater than their age when the epidemic visited the colony. The life shortening estimates in Table 1 have been based on *average* life span, including all animals in the calculation except those dying "acutely" within sixty days after irradiation. This treatment neglects the greater potential survival of rats killed by infection and probably acts to underestimate slightly the life shortening effect.

DISCUSSION

The life span reduction by roentgen irradiation resembles acute effects such as thirty day lethality, erythema, blood dyscrasias, etc., since in both cases a single dose produces a greater effect than the same total dose delivered in daily fractions. The underlying cause of this finding is believed to be quite different in the two classes of effects. The injury manifested in the acute effects is, short of death, known to be subject to body repair, enabling a reduction of the injury level during the interval between dose fractions. By contrast, the life shortening injury, since it may become manifest a year or so (in the rat) after irradiation, is almost by definition irreparable. Therefore, the cause of the reduced effect must be attributed to processes in the production of life shortening injury rather than subsequent modification of injury once established.

It may be postulated (1) that the amount of injury produced by a single dose depends on some power function of the dose size, or (2) that the proportionality constant relating dose and injury is larger for the high dose size region than for the constant low dose size region. A biological model for a step function of the sort proposed in alternative 2 might involve a system which accumulated injury in linear proportion to dose over a range of low dose sizes but which, as the single dose size was increased and a new injury eliciting mechanism was triggered, accumulated injury at a higher proportional rate. The statistical uncertainty of the experimental data does not permit the rejection of either of these postulated mechanisms.

Since the dose rate was the same for the high and low doses in Experiment II, it is emphasized that single dose size, and not dose rate, is the significant variable. "Single dose" in this context is defined as a dose delivered within a few hours or less.

From a radiological health physics point of view the result of the second experiment is somewhat reassuring. The result of the first experiment alone permits the conjecture that if the rat results may be extrapolated to man, and if the reduction in life span be at the rate of 30 per cent per 1,000 r, a man exposed to roentgen or gamma radiation at the maximal permissible level of 15.6 r per year for fifteen years might suffer on the average a 7 per cent reduction in life span. The second experiment modifies this interpretation and makes it likely that with the low postulated "dose size," the average reduction in life span would be less than 2 per cent because of the dose size effect. At this level the life shortening consequences of roentgen-ray exposure are perhaps dwarfed by other hazards of life in modern society.

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THE LETHAL DOSE OF TOTAL BODY COBALT-60 GAMMA RADIATION FOR THE RABBIT*

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AN ESTIMATION of the $LD_{50/30}$† for a commonly used laboratory animal exposed to gamma rays, and having a known $LD_{50/30}$ value for roentgen rays, was needed in order that a comparison could be made with data obtained for the burro and swine by Rust *et al.*[9,10] This report describes the methods used and the results obtained for the $LD_{50/30}$, mean survival time and of the death pattern of rabbits exposed to total body radiation of gamma rays from cobalt-60.

MATERIALS AND METHOD

Animals. The rabbits were young sexually mature females of mixed breeding (7 mature males were used in the 1,000 r group), uniform in size and in apparent good health. The animals were randomly placed in lots of 10 for the experimental study. Rabbit pellets and water were available to the animals at all times.

Exposure. The exposure field is a circular concrete pad with 19 derricks which support the radioactive sources distributed in a concentric hexagonal pattern to deliver a reasonable uniform photon flux. This was designed for large animals and has been described in detail by Wilding *et al.*[11] The animals were exposed in rabbit hutches, located in the field as indicated (Fig. 1).

The field was charged with radioactive cobalt-60 which was encased in 2 mm. thick brass tubing. The distance of the rabbits from the nearest source was 85 cm. or more in all cases. The charges were lifted 6–8 inches above the level of the animals which insured against a shadowing effect by the animals nearest the radioactive source. Exposures to 1,380, 1,500, 1,600, 1,700, and 1,800 r were made and a few weeks later the remaining groups were exposed to 800, 900, 1,000, 1,100, and 1,200 r. The rate of exposure for the first lots was 48.3 r/hour and 47 r/hour for the second group. Following exposure the animals were observed for thirty days.

Dosimetry. The dose rate was expressed in roentgens per hour in air. The radiation rate for various points about the exposure hutches was obtained with 100 r Victoreen thimble chambers which were corrected for barometric pressure and temperature changes and finally corrected to a standardized‡ 25 r Victoreen chamber.

RESULTS AND DISCUSSION

Eight hundred roentgens of total body radiation was not lethal to rabbits. Doses above 1,500 r were 100 per cent lethal (Table 1). The $LD_{50/30}$ of 1,094 r, with a confidence interval of 1,006–1,172 r, was

TABLE I

LETHAL RESPONSE OF RABBITS TO TOTAL BODY IRRADIATION

(10 animals at each dose level)

Dose (r)	Mortality (per cent)	Dose Rate (r/hr.)	Exposure Time (hr.)
800	0	47.0	17.0
900	30	47.0	19.2
1,000	30	47.0	21.3
1,100	30	47.0	23.4
1,200	90	47.0	25.5
1,380	80	48.3	28.6
1,500	100	48.3	31.1
1,600	100	48.3	33.2
1,700	100	48.3	35.2
1,800	100	48.3	37.3

† The $LD_{50/30}$ is that statistically estimated dose of radiation which will kill one-half of the tested animals within thirty days.

‡ National Bureau of Standards.

* From the University of Tennessee Atomic Energy Commission, Agricultural Research Program, Oak Ridge, Tennessee.

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[2] Present address: Room 206, Post Office Building, Guntersville, Alabama.

[3] Lieutenant Colonel, Veterinary Corps, United States Army.

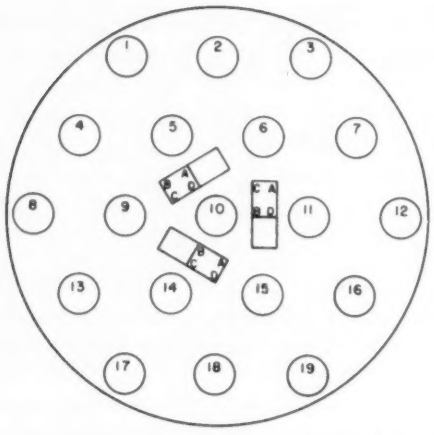

FIG. 1. The arrangement of the exposure site for the irradiation of the rabbits. At the center of each of the inner circles (1 through 19) a cylinder of cobalt-60 was located. Within the hutches at the points A, B, C, and D measurements were made with Victoreen thimble chambers. The hutches were divided as indicated to prevent the rabbits from huddling and shielding each other. The diameter of the field is 50 feet.

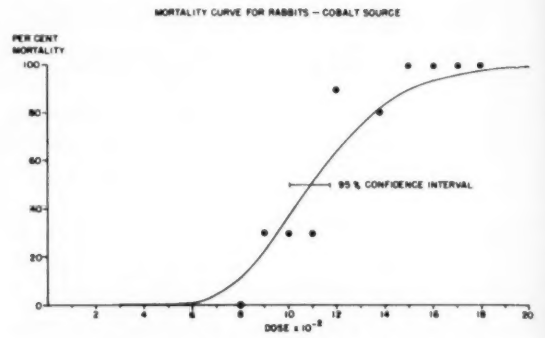

FIG. 2. The sigmoid curve derived by the Bliss-Fisher method. The dots represent test points. The dose is in roentgens.

obtained by the Bliss-Fisher probit method[1] (Fig. 2).

The distribution of deaths (Fig. 3) indicates a unimodal pattern in contrast to a trimodal pattern reported by others.[4] The mean survival time was 9.1 days with the highest incidence of death on the eighth day. However, the survival time was significantly affected by dose (Table II). Other workers are agreed (Table III) that the $LD_{50/30}$ was about 800 r for the rabbit exposed to 200 kv. (peak) roentgen rays filtered to have a half-value layer of 0.98 mm. of copper and administered at a rate of 12–16 r per minute. The $LD_{50/30}$ under conditions of this experiment was significantly higher. Two experimental factors are perhaps major contributors to this difference between the $LD_{50/30}$. The dosage rates were different, as indicated by the value 900 r/hr. for the roentgen rays compared with that of 48 r/hr. for the cobalt-60 gamma-ray exposure and the energies of the photons were different. The 200 kv. (peak) roentgen rays have a half-value layer of 0.98 mm. of copper while the 1.25 mev. gamma rays (the average of the two cascading photons) of cobalt-60 have a corresponding value of 7.3 mm.

It has been observed by many workers that the slower the rate of administration of total body radiation, the less effective per roentgen is the treatment. Henshaw *et al.*[5] exposed mice to tantalum-182 gamma rays and found that a decrease of rate from 30 r/min. to 3 r/min., a tenfold change, reduced the effectiveness, as measured by $LD_{50/30}$, to about 70 per cent. A more complete discussion of this problem of time-intensity relationship can be found in a review and discussion by McLean *et al.*[7]

In addition Lea[6] has commented extensively upon the reduction of effectiveness of ionizing radiations as the linear ion

TABLE II

MEAN SURVIVAL TIME BY DOSE GROUPS OF ANIMALS DYING WITHIN 30 DAYS AFTER EXPOSURE

Dose (r)	900	1,000	1,000	1,200	1,380	1,500	1,600	1,700	1,800
Mean survival time (days)	15.67	15.0	10.67	9.33	10.63	7.9	8.7	7.5	6.7
No. of animals dead	3	3	3	9	8	10	10	10	10

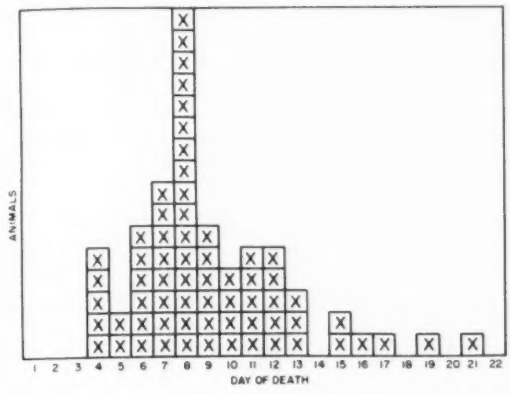

FIG. 3. The distribution of deaths without respect to dose. The response is definitely unimodal.

density increased or as the wavelength shortens, with various biological materials such as viruses and *Tradescantia* microspores. Rust *et al.*[10] have observed and commented upon this same phenomenon when burros and swine were exposed to photons of different energies. The relative contribution of quality of radiation and rate of administration to the difference in LD_{50}s cannot be estimated from these data. Plans are in progress to test the relative biologic effectiveness of a gamma-ray flux of a different linear ion density at the same intensity as the cobalt-60 gamma flux.

SUMMARY

1. One hundred mature rabbits were exposed in groups of 10 to the gamma rays of cobalt-60 at the rate of approximately 45 r per hour. The $LD_{50/30}$ was 1,094 r and the confidence interval was 1,006–1,172 r.

2. The mean survival time decreased as the dose increased and for all animals succumbing it was 9.1 days. The death pattern was unimodal.

3. These data when compared with values for roentgen rays in the literature are in agreement with the general findings that a decreased dose rate and increased energy tend to reduce the effectiveness of the radiation.

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The statistical analysis was done by Dr. A. W. Kimball, Jr., Mathematics Panel, Oak Ridge National Laboratory, Oak Ridge, Tennessee. The maintenance of the animals was under the supervision of Mr. John R. Paysinger, of this laboratory. Dr. C. S. Simons of the Training Division, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee (Present address: Department of Radiology, The University of Michigan, Ann Arbor, Mich.), made the dose measurements.

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TABLE III

LETHAL DOSE AND PHYSICAL FACTORS

Authors	Breed	Volts	Half-Value Layer	Filtration	Rate	$LD_{50/30}$ (r)
Hagen and Zirkle[4]*	Swift	200 kv.p.	0.98 mm. Cu	0.5 mm. Cu and 1.0 mm. Al	15 r/min.	825
This paper	Mixed	1.25 mev.	7.3 mm. Cu	2.0 mm. brass	47–48.3 r/hr.	1,094

* Hagen and Sacher,[3] Hagen *et al.*[2] and Prosser *et al.*[8] have also reported upon these animals, either in whole or in part.

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THE AMERICAN JOURNAL OF ROENTGENOLOGY, RADIUM THERAPY AND NUCLEAR MEDICINE

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Thirty-eighth Annual Meeting: Shamrock Hotel, Houston, Texas, April 9–11, 1956.

EDITORIALS

THE ANNUAL MEETING OF THE AMERICAN ROENTGEN RAY SOCIETY

THE Fifty-sixth Annual Meeting of the American Roentgen Ray Society will be held at the Palmer House, Chicago, Illinois, September 20, 21, 22 and 23, 1955. The Society returns to the Palmer House conscious of the facilities which the hotel offers as a meeting place for a society as large and comprehensive as the American Roentgen Ray Society. President-Elect Paul C. Hodges has arranged an interesting scientific program.

Elsewhere in this issue of the JOURNAL is to be found President-Elect Hodges' program. A perusal of this will convince everyone that it is a comprehensive one, covering as it does, in a selected range of papers, the therapeutic as well as the diagnostic and experimental aspects of radiology, and there will also be found a group of papers on subjects which should make a special appeal to all interested in radiology. Various symposiums have been arranged among which is one entitled "New Departures in Diagnostic Radiology" with Dr. Fred J. Hodges of Ann Arbor, Michigan, presiding. There is a group of six papers in this symposium ranging from "Circulatory Dynamics" to "High Tension Switch-Tube for Radiography."

On Tuesday evening the annual Caldwell Lecture is to be given by Professor Lester R. Dragstedt who is Thomas D. Jones Professor and Chairman of the Department of Surgery of the University of Chicago, Chicago, Illinois. Professor Dragstedt has chosen as the topic for his discussion "A New Concept of the Etiology of Duodenal and Gastric Ulcer." Needless to say, this will be one of the highlights of the meeting as no one speaks with greater authority on the subject of duodenal and gastric ulcer than does Professor Dragstedt. The introduction of Professor Dragstedt is to be made by Dr. Egbert H. Fell of Chicago, Illinois, and the presentation of the Caldwell Medal to Dr. Dragstedt will be made by President Hodges.

On Wednesday there is a symposium dealing with "Gastrointestinal Diseases." Presiding will be Dr. Frederic E. Templeton of Seattle, Washington. This symposium of eight papers will cover a wide range of discussion of the various aspects of gastrointestinal diseases and should be of interest to all those in attendance.

On Thursday there will be an extensive program dealing with various aspects of radiation therapy, among which will be a symposium on "Supervoltage and Megavoltage Radiation Therapy with Various Sources." Presiding at this symposium will be Dr. Traian Leucutia of Detroit, Michigan.

On Thursday evening the Annual Banquet will be held at which time the presentation of the awards for the scientific exhibits will be made. Dr. C. Allen Good, Chairman of the Scientific Exhibit Committee, has collected an excellent group of exhibits dealing with all phases of radiology which should attract a great deal of attention.

On Friday the scientific program is of a more general character and, as may be seen from the preliminary program, the papers have all been arranged with considerable thought and will undoubtedly prove of great interest.

The Instruction Courses which have become a splendid part of the annual meetings of the Society will be held in the afternoon of each day of the meeting. Dr. Harry M.

Weber is the director of the Instruction Courses and he has in his customary efficient manner gathered together an outstanding faculty to give these courses.

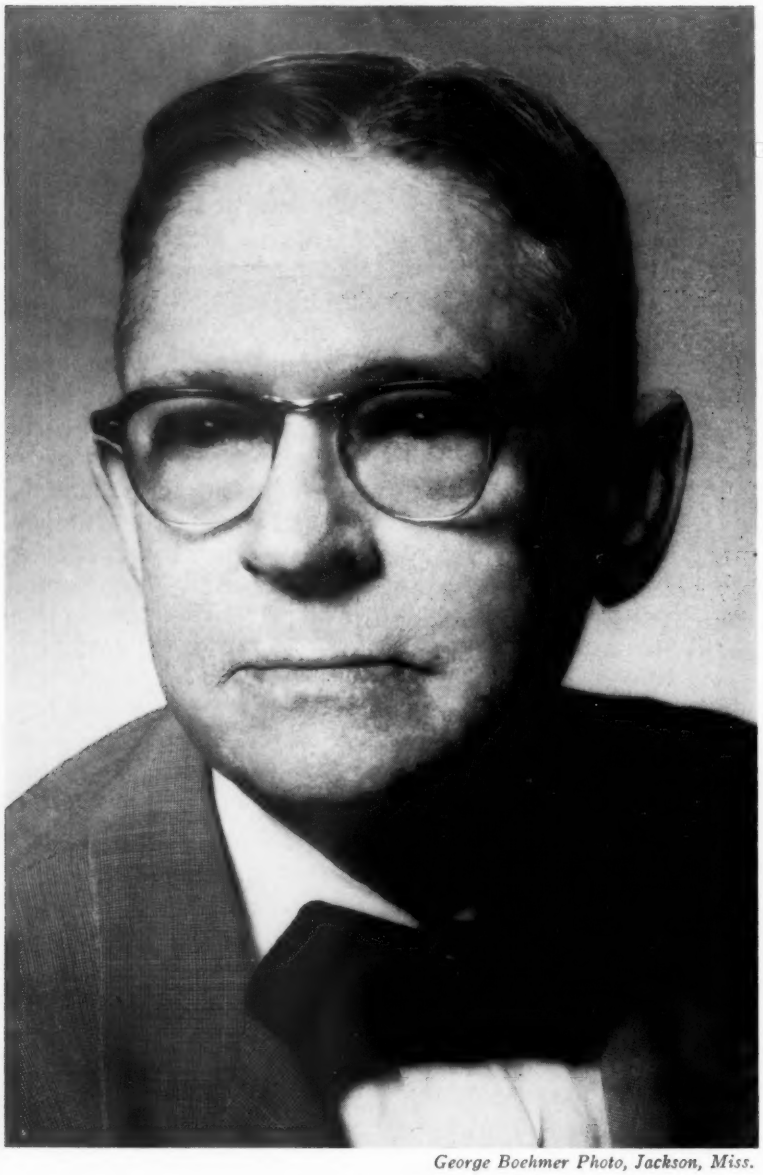
As has been the custom at the last several meetings of the Society, ample time will be allotted for the study of the Scientific and Commercial Exhibits.

The annual Golf Tournament for members for the Willis F. Manges Trophy and for members and guests for the Exhibitors Trophy will be held on Monday, September 19, at the Edgewater Golf Club, and the annual Golf Dinner will be held at the same place following the tournament. The arrangements have been made by the Local Committee under the chairmanship of Dr. Earl E. Barth.

The Ladies Committee, under the chairmanship of Mrs. Earl E. Barth, has arranged interesting events for the ladies. Chicago also offers many places of historical interest, and its wonderful museums and its splendid Planetarium should make a great appeal to all who attend the meeting.

The Commercial Exhibits, which are always an important part of the annual meetings, will be held in close proximity to the scientific assembly room and it is anticipated that there will be a large number of commercial exhibits presenting the latest styling and designs not only in the appearance of radiological equipment but showing the great improvements that have been made in the functioning of radiological equipment within the last several years.

All in all, the meeting at the Palmer House in Chicago should be an excellent one and those who anticipate going to the meeting should make their reservations immediately as a large attendance is anticipated.



George Boehmer Photo, Jackson, Miss.

WILLIAM ROLAND BETHEA
1880-1954

DR. WILLIAM ROLAND BETHEA, one of the true pioneers of the Radiological Profession in the South, died in Jackson, Mississippi, August 24, 1954, after a long illness. Dr. Bethea was born October 27, 1880, at Hebron, Mississippi, and received his public school education in Hebron.

He received his doctor of medicine degree from the University of Nashville, which is now the University of Tennessee, in 1905. Following graduation he returned to Hebron where he was engaged in the general practice of medicine from 1905 to 1911. In 1911 he moved to Hattiesburg, Mississippi, where he again practiced gen-

eral medicine but became interested in radiology. From 1911 to 1917 he gradually began to limit his practice to the field of radiology and during this time he received post-graduate work from Tulane University, New Orleans, Louisiana. In 1917, Dr. Bethea volunteered for military service in World War I and was commissioned a Captain in the Medical Corps of the United States Army and sent to Johns Hopkins University for training in radiology. Following this period of training he was assigned to the Base Hospital at Camp Shelby, in Hattiesburg, Mississippi, and remained there from August 25, 1917 to September 24, 1919. During this time he was head of the x-ray department, as well as commanding officer of the Base Hospital for a period. He was discharged as a Major in the Medical Corps and remained in the Reserve until approximately 1933 at which time he resigned his commission as Lieutenant Colonel.

Following his discharge from the military service he was appointed head of the Department of Radiology at the Baptist Memorial Hospital, in Memphis, Tennessee, in January, 1920. While head of this department he wrote many scientific papers, prepared radiological exhibits and in 1922 was Chairman of the Section of Radiology of the Southern Medical Association. He remained at the Baptist Hospital, in Memphis, until 1938 at which time he went into the private practice of radiology in Memphis for two years. At the end of this period he transferred his office to Jackson, Mississippi, and was engaged there in the private practice of radiology until his death.

Dr. Bethea was not content to take a passive interest in life but throughout his entire adult career he was engaged in many varied fields of civic endeavor. He was extremely active in church and religious work and was a deacon in the First Baptist Church in each of the three cities in which he practiced, Hattiesburg, Memphis, and Jackson. He was also a member of the Rotary Club in each of these three places and took an active and special interest in Scout Work during this time and received the Silver Beaver award for his special contributions to this activity. He was also vitally interested in hunting and fishing and was a member of Ducks Unlimited, the Conservation League and Wild-Life Club. He was a member of the American Red Cross, Y.M.C.A., American Legion, the Chamber of Commerce of Jackson, Mississippi, and was a Shriner.

His professional memberships included the American Medical Association, the Central Medical Society of the State of Mississippi, the Southern Medical Association, the Radiological Society of North America, the American College of Radiology, the American Roentgen Ray Society. He was a diplomate of the American Board of Radiology and the first President of the Mississippi Radiological Society.

He is survived by his wife, the former Agnes Polk, of Hattiesburg, Mississippi, three sons, W. R. Bethea, Jr., M.D., Ralph Chambers Bethea, M.D., and David Polk Bethea.

The passing of Dr. Bethea leaves an irreplaceable niche in the memory of professional men and the lay public alike in the State of Mississippi in particular, and the South in general. He was a true friend and one upon whom many of the younger men of the medical profession relied for a firm steadying influence as well as wise counsel.

John W. Evans, M.D.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

MEETINGS OF RADIOLOGICAL SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. Barton R. Young, Germantown Hospital, Philadelphia 44, Pa. Annual meeting: Palmer House, Chicago, Ill., Sept. 20–23, 1955.

AMERICAN RADIUM SOCIETY
Secretary, Dr. R. E. Fricke, Mayo Clinic, Rochester, Minn. Annual meeting: Shamrock Hotel, Houston, Texas, April 9–11, 1956.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 713 E. Genesee St., Syracuse 2, N. Y. Annual meeting: Palmer House, Chicago, Ill., Dec. 11–16, 1955.

AMERICAN COLLEGE OF RADIOLOGY
Executive Secretary, William C. Stronach, 20 N. Wacker Drive, Chicago 6, Illinois. Annual meeting: 1956, to be announced.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. T. Leucutia, Harper Hospital, Detroit 1, Mich. Annual Meeting: 1956, to be announced.

EIGHTH INTERNATIONAL CONGRESS OF RADIOLOGY
Secretary General, Dr. José Noriega, Calle del Oro 15, Mexico 7, D. F. Meets Mexico City, July 22–28, 1956.

ALABAMA RADIOLOGICAL SOCIETY
Secretary, Dr. J. A. Meadows, Jr., Medical Arts Bldg., Birmingham 5, Ala. Meets time and place Alabama State Medical Association.

ARIZONA RADIOLOGICAL SOCIETY
Secretary, Dr. R. Lee Foster, 507 Professional Bldg., Phoenix, Ariz. Two regular meetings a year. The annual meeting at time and place of State Medical Association and interim meeting six months later.

ARKANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. J. A. Norton, 843 Donaghey Bldg., Little Rock, Ark. Meets every three months and also at time and place of State Medical Association.

ATLANTA RADIOLOGICAL SOCIETY
Secretary, Dr. Albert A. Rayle, Jr., 478 Peachtree St., N.E., Atlanta, Ga. Meets monthly, except during three summer months, on second Friday evening.

BROOKLYN RADIOLOGICAL SOCIETY
Secretary, Dr. Daniel G. Butera, 709 E. 39th St., Brooklyn, N. Y. Meets first Thursday of each month October through April.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. J. J. Daversa, 345 75th St., Brooklyn, N. Y. Meets monthly fourth Tuesday, October through April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Clayton G. Weig, 135 Linwood Ave., Buffalo, N. Y. Meets second Monday evening each month, October to May inclusive.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. Dwight V. Needham, 608 E. Genesee St., Syracuse, N. Y. Meets January, May, November.

CENTRAL OHIO RADIOLOGICAL SOCIETY
Secretary, Dr. F. A. Riebel, 15 West Goodale St., Columbus, Ohio. Meets at 6:30 P.M. on second Thursday of October, December, February, April, and June at Columbus Athletic Club, Columbus, Ohio.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. E. Burns Lewis, 670 N. Michigan Ave., Chicago 11, Ill. Meets second Thursday of each month, October to April inclusive at the Sheraton Hotel.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. H. F. Inderlied, 11311 Shaker Blvd., Cleveland 4, Ohio. Meetings at 6:45 P.M. on fourth Monday of each month from October to April.

COLORADO RADIOLOGICAL SOCIETY
Secretary, Dr. S. A. Patterson, Larimer County Hospital, Fort Collins, Colo. Meets third Friday of each month at University of Colorado Medical Center or at Denver Athletic Club.

CONNECTICUT VALLEY RADIOLOGIC SOCIETY
Secretary, Dr. B. B. Alicandri, 20 Maple St., Springfield, Mass. Meets second Friday October and April.

DALLAS-FORT WORTH RADIOLOGICAL CLUB
Secretary, Dr. A. H. Keene, 3707 Gaston Ave., Dallas, Texas. Meets monthly, third Monday, at Greater Fort Worth International Airport at 6:30 P.M.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. F. Lang, Harper Hospital, Detroit, Mich. Meets monthly first Thursday, Oct. through May, at David Whitney House, 4421 Woodward Ave., at 6:30 P.M.

EAST BAY ROENTGEN SOCIETY
Secretary, Dr. Dan Tucker, 434 30th St., Oakland 9, Calif. Meets first Thursday each month at Peralta Hospital, Oakland.

FLORIDA RADIOLOGICAL SOCIETY
Secretary, Dr. D. H. Gahagen, 320 Sweet Bldg., Fort Lauderdale, Fla. Meets twice annually, in the spring with the annual State Society meeting, and in the fall.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. B. H. Malone, 1406 Reynolds St., Brunswick, Ga.

GREATER MIAMI RADIOLOGICAL SOCIETY
Secretary, Dr. A. S. Capi, 300 N. 20th Ave., Hollywood, Fla. Meets monthly third Wednesday at 8 P.M. at various South Florida Hospitals.

HOUSTON RADIOLOGICAL SOCIETY
Secretary, Dr. W. C. Owsley, 6409 Fannin, Houston 25, Texas. Meets fourth Monday each month at Texas Children's Hospital.

IDAHO STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Alfred M. Stone, St. Lukes Hospital, Boise, Idaho. Meets annually at same time as Idaho State Medical Association.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Stephen L. Casper, 1101 Maine St., Quincy, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. C. A. Stayton, 313 Hume-Mansur Bldg., Indianapolis 4. Meets first Sunday in May and during fall meeting of Indiana State Medical Association.

IOWA RADIOLOGICAL SOCIETY
Secretary, Dr. James T. McMillan, 1104 Bankers Trust Bldg., Des Moines, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society, The scientific section is held in the autumn.

KANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. A. M. Cherner, Hays, Kansas. Meets in spring with State Medical Society, and in winter on call.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. David Shapiro, 217 East Chestnut St., Louisville 2, Ky. Meets monthly on second Friday at Seelbach Hotel, Louisville.

* Secretaries of societies are requested to send timely information promptly to the Editor.

Kings County Radiological Society
Secretary, Dr. Solomon Maranov, 1450 51st St., Brooklyn 19, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:45 P.M.

Los Angeles Radiological Society
Secretary, Dr. Oscar Harvey, 3741 Stocker St., Los Angeles 8, Calif. Meets second Wednesday each month at Los Angeles County Medical Association Building, Los Angeles.

Maine Radiological Society
Secretary, Dr. W. A. Russell, Augusta General Hospital, Augusta, Maine. Meets in June, October, December and April.

Maryland Radiological Society
Secretary, Dr. Paul W. Roman, 1810 Eutaw Place, Baltimore 17, Maryland.

Memphis Roentgen Society
Secretary, Dr. B. E. Greenberg, 294 Annella St., Memphis 11, Tenn. Meets first Monday of each month at John Gaston Hospital.

Miami Valley Radiological Society
Secretary, Dr. G. A. Nicoll, 134 Apple St., Dayton, Ohio. Meets second Friday of fall and winter months.

Mid-Hudson Radiological Society
Secretary, Dr. J. W. Walton, Horton Memorial Hospital, Middletown, N. Y. Meets 8:30 P.M., fourth Tuesday each month, September to May.

Milwaukee Roentgen Ray Society
Secretary, Dr. R. W. Byrne, 3321 N. Maryland Ave., Milwaukee 1, Wis. Meets monthly on fourth Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. John R. Hodgson, Mayo Clinic, Rochester, Minn. Meets three times annually, once at time of State Med. Assn., and in spring and fall.

Mississippi Radiological Society
Secretary, Dr. James M. Packer, 621 High St., Jackson, Miss. Meets third Thursday of each month at Hotel Edwards, Jackson, at 6:00 P.M.

Montana Radiological Society
Secretary, Dr. Grant P. Raitt, Suite 413 Medical Arts Bldg., Billings, Montana. Meets at least once a year.

Nassau Radiological Society
Secretary, Dr. Alan E. Baum, Hicksville, N. Y. Meets second Tuesday of the month in February, April, June, October and December.

Nebraska Radiological Society
Secretary, Dr. J. F. Kelly, Jr., 816 Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month at 6 P.M. in Oamaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. Stanley M. Wyman, Massachusetts General Hospital, Boston, Mass. Meets third Friday of each month, October through May, at Hotel Commander, Cambridge, Mass.

New Hampshire Roentgen Ray Society
Secretary, Dr. A. C. Johnston, Elliott Community Hospital, Keene, N. H. Meets four to six times yearly.

New York Roentgen Society
Secretary, Dr. Sidney Rubenfeld, 477 First Ave., New York 16, N. Y. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

North Carolina Radiological Society
Secretary, Dr. W. C. Sternbergh, Charlotte Memorial Hospital, Charlotte, N. C. Meets in May and October.

North Dakota Radiological Society
Secretary, Dr. Marianne Wallis, St. Joseph's Hospital, Minot, N. Dak. Meetings by announcement.

North Florida Radiological Society
Secretary, Dr. Ivan Isaacs, 1645 San Marco Blvd., Jacksonville, Florida. Meets quarterly in March, June, September and December.

Northeastern New York Radiological Society
Secretary, Dr. D. H. Baxter, Albany Hospital, Albany, N. Y. Meets in Albany area on second Wednesdays of October, November March and April.

Northern California Radiological Society
Secretary, Dr. H. B. Stewart, 2920 Capitol Ave., Sacramento, Calif. Meets at dinner last Monday of each month, September to June.

Ohio State Radiological Society
Secretary, Dr. M. M. Thompson, Jr., 319 Toledo Medical Bldg., Toledo 2, Ohio. Annual meeting, Mayflower Hotel, Akron, Ohio, May 20–22, 1955.

Oklahoma State Radiological Society
Secretary, Dr. John R. Danstrom, Medical Arts Bldg., Oklahoma City, Okla. Three regular meetings annually.

Oregon Radiological Society
Secretary, Dr. F. C. Shipps, 214 Medical-Dental Bldg., Portland 5, Oregon. Meets monthly from October to June on the second Wednesday of each month at 8:00 P.M. at the University Club.

Orleans Parish Radiological Society
Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets first Tuesday of each month.

Pacific Northwest Radiological Society
Secretary, Dr. J. R. Raines, 214 Medical-Dental Bldg., Portland 5, Oregon. Meets annually in May.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. J. M. Converse, 416 Pine St., Williamsport.

Philadelphia Roentgen Ray Society
Secretary, Dr. H. M. Stauffer, Temple University Hospital, Philadelphia 40, Pa. Meets first Thursday of each month, at 5 P.M., from October to May in Thompson Hall, College of Physicians.

Pittsburgh Roentgen Society
Secretary, Dr. Donald H. Rice, Western Pennsylvania Hospital, Pittsburgh 24, Pa. Meets second Wednesday of month, October through June at Hotel Roosevelt.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Paul W. Roman, 1810 Eutaw Place, Baltimore 17, Md. Meets third Tuesday each month, September to May, inclusive.

Radiological Section, Connecticut Medical Society
Secretary, Dr. William A. Goodrich, 85 Jefferson St., Hartford 6, Conn. Meetings are held bi-monthly.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Radiological Society of Greater Cincinnati
Secretary, Dr. Wm. R. Dickens, Cincinnati General Hospital, Cincinnati 29, Ohio. Meets monthly from September to June on first Monday of each month at 7:30 P.M. at the Cincinnati General Hospital.

Radiological Society of Hawaii
Secretary, Dr. H. C. Chang, 1282 Emma St., Honolulu 13, T. H. Meets third Monday evening of each month at designated hospitals.

Radiological Society of Greater Kansas City
Secretary, Dr. E. H. Stratemeier, Jr., 1010 Rialto Building, Kansas City 6, Mo. Meets last Friday of each month.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

Radiological Society of Louisiana
Secretary, Dr. J. T. Brierre, 700 Audubon Bldg., New Orleans. Meets annually during Louisiana State Medical Society Meeting.

Radiological Society of New Jersey
Secretary, Dr. G. G. Green, 601 Grand Ave., Asbury Park, N. J. Meets at Atlantic City at time of State Medical Society and in November in Newark, N. J.

Radiological Society of Southern California
Secretary, Dr. George Jacobson, 1200 N. State St., Los Angeles 33, Calif.

Richmond County Radiological Society
Secretary, Dr. W. F. Hamilton, Jr., University Hospital,

Augusta, Ga. Meets first Thursday of each month at various hospitals.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. Henry H. Forsyth, Jr., 40 Meigs St., Rochester, N. Y. Meets at 8:15 P.M. on the last Monday of each month, September through May, at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY
Secretary, Dr. John H. Freed, 4200 East Ninth St., Denver 7, Colo. Mid-Summer Conference, Shirley-Savoy Hotel, Denver, Colo., Aug. 18–20, 1955.

ST. LOUIS SOCIETY OF RADIOLOGISTS
Secretary, Dr. Edwin C. Ernst, Jr., 3720 Washington Ave., St. Louis 8, Mo. Meets fourth Wednesday each month, except June, July, Aug. and Sept.

SAN ANTONIO-MILITARY RADIOLOGICAL SOCIETY
Secretary, Dr. Hugo F. Elmendorf, Jr., 730 Medical Arts Bldg., San Antonio 5, Texas Meets Brooke Army Medical Center Officers Mess first Monday of each month.

SAN DIEGO RADIOLOGICAL SOCIETY
Secretary, Dr. J. C. Asher, 2001 Fourth Ave., San Diego 1, Calif. Meets first Wednesday of each month at the University Club.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. T. M. Fullenlove, 110 El Verano Way, San Francisco 27, Calif. Meets quarterly at Grison's Steak House.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION
Secretary, Dr. H. R. Morris, 1027 "D" St., San Bernardino, Calif.

SECTION ON RADIOLOGY, MEDICAL SOCIETY OF THE DISTRICT OF COLUMBIA
Secretary, Dr. John A. Long, 1801 K St., N.W., Washington 6, D. C. Meets Medical Society Library, third Wednesday of January, March, May and October at 8:00 P.M.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. George E. Irwin, Jr., 703 N. East St., Bloomington, Ill.

SHREVEPORT RADIOLOGICAL CLUB
Secretary, W. R. Harwell, 608 Travis St., Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M. September to May inclusive.

SOUTH BAY RADIOLOGICAL SOCIETY
Secretary, Dr. T. N. Foster, 630 E. Santa Clara St., San Jose, Calif. Meets second Wednesday of each month.

SOUTH CAROLINA RADIOLOGICAL SOCIETY
Secretary, Dr. William A. Klauber, Self Memorial Hospital, Greenwood, S. C. One meeting with South Carolina Medical Association in May, others arranged by President.

TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. G. K. Henshall, 311 Medical Arts Bldg., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY
Secretary, Dr. R. P. O'Bannon, 650 Fifth Ave., Fort Worth 4, Texas. Next Meeting, Fort Worth, Texas, Jan. 20–21, 1956.

TRI-STATE RADIOLOGICAL SOCIETY
Secretary, Dr. S. N. Tager, 219 Walnut St., Evansville, Ind. Meets last Wednesday of Oct., Jan., March and May, 8:00 P.M. at Elks' Club in Evansville.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING
Meets each Monday evening from September to June, at 7:00 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets first and third Thursdays 4:00 to 5:00 P.M., September to May, Service Memorial Institute.

UTAH STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Angus K. Wilson, 343 S. Main St., Salt Lake City 1, Utah. Meets fourth Wednesday in January, March, May, September and November at Holy Cross Hospital.

VIRGINIA RADIOLOGICAL SOCIETY
Secretary, Dr. P. B. Parsons, Norfolk General Hospital, Norfolk, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Eva L. Gilbertson, 1317 Marion St., Seattle 4, Wash. Meets fourth Monday of each month from September through May at 610 Pine St., Seattle.

WEST VIRGINIA RADIOLOGICAL SOCIETY
Secretary, Dr. W. Paul Elkin, 515 Medical Arts Bldg., Charleston, W. Va. Meets concurrently with annual meeting of West Virginia State Medical Society; other meetings arranged by program committee.

WESTCHESTER RADIOLOGICAL SOCIETY
Secretary, Dr. M. G. Priestman, New Rochelle Hospital, New Rochelle, N. Y. Meets on third Tuesday of January and October and on two other dates.

WISCONSIN RADIOLOGICAL SOCIETY
Secretary, Dr. W. W. Moir, 309 Geele Ave., Sheboygan, Wis. Special meetings held during year; annual meeting each spring at Madison, Wis.

X-RAY STUDY CLUB OF SAN FRANCISCO
Secretary, Dr. J. T. English, 2000 Van Ness Ave., San Francisco 9, Calif. Meets monthly, third Thursday at 7:45 P.M., Lane Hall, Stanford University Hospital.

CUBA, MEXICO, PUERTO RICO AND CENTRAL AMERICA

SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

SOCIEDAD MEXICANA DE RADIOLOGÍA, A. C.
Calle del Oro No. 15, Mexico 7, D. F.
Secretary General, Dr. Guillermo Santín. Meets first Monday of each month.

ASOCIACIÓN PUERTORRIQUEÑA DE RADIOLOGÍA
Secretary, Dr. Rafael A. Blanes, P. O. Box 9067, Santurce, Puerto Rico.

SOCIEDAD RADIOLÓGICA PANAMEÑA
Secretary, Dr. L. Arrieta Sanchez, Apartado No. 86, Panama, R. de P. Meets monthly in a department of radiology of a local hospital, chosen at preceding meeting.

BRITISH EMPIRE

ASSOCIATION OF RADIOLOGISTS OF THE PROVINCE OF QUEBEC
Secretary, Dr. Jean-Louis Léger, 1560 Sherbrooke St., Montreal, Que. Meets four times a year.

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Ordinary meeting, on the Thursday preceding the third Friday, October to May at 8:15 P.M.
Medical Members' meeting, on third Friday in each month at 5:00 P.M., 32 Welbeck St., London, W 1

FACULTY OF RADIOLOGISTS
Honorary Secretary, Dr. R. A. Kemp Harper, 45, Lincoln's Inn Fields, London, W.C.2, England.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets third Friday each month at 4:45 P.M. at the Royal Society of Medicine, 1 Wimpole St., London.

CANADIAN ASSOCIATION OF RADIOLOGISTS
Honorary Secretary-Treasurer, Dr. D. L. McRae, Suite 305, 1555 Summerhill Avenue, Montreal 25, Que. Meetings January and June.

SECTION OF RADIOLOGY, CANADIAN MEDICAL ASSOCIATION
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

SOCIÉTÉ CANADIENNE-FRANÇAISE D'ELECTRO-RADIOLOGIE MÉDICALES
General Secretary, Dr. Ls Ivan Vallée, 1058 rue St-Denis, Montreal 18, Canada. Meets third Saturday each month.

COLLEGE OF RADIOLOGISTS (AUSTRALIA AND NEW ZEALAND)
Honorary Secretary, Dr. Alan R. Colwell, c/o British Medical Agency, 135 Macquarie St., Sydney, N.S.W.

SOUTH AMERICA

ASOCIACION ARGENTINA DE RADIOLOGIA
Secretary, Dr. Lidio G. Mocsa, Avda. Gral. Paz 151 Córdoba, Argentina. Meetings held monthly.

Sociedad Argentina de Radiologia, Junta Central, Buenos Aires
Secretary, Dr. Oscar F. Noguera, Santa Fe 1171, Buenos Aires. Meetings are held monthly.

Sociedad Argentina de Radiologia, Filial del Litoral, Sede, Rosario
President, Dr. Francisco P. Cifarelli. Meets monthly second Wednesday, 19 ha 663 Italia St., Rosario, Santa Fe.

Sociedad Argentina de Radiologia, Filial del Sur, Sede, La Plata
President, Prof. Dr. Jose P. Uslenghi, La Plata. Meets monthly.

Sociedad Argentina de Radiologia, Filial del Centro Sede, Córdoba
President, Prof. Dr. David L. Caro, Corro 86, Córdoba. Meets monthly.

Sociedad Argentina de Radiologia, Filial del Norte, Sede, Tucuman
President, Dr. Julio Mendez Valladares, Rivadavia 358, Tucuman. Meets monthly.

Sociedad Argentina de Radiologia, Filial de Cuyo Sede, Mendoza.
President, Dr. J. A. Orfila, Hospital Central, Mendoza. Meets monthly.

Sociedade Brasileira de Radiologia Medica
Secretary, Dr. Nicola Caminha, Av. Mem. de Sa, Rio de Janeiro, Brazil. Meets monthly, except during January, February and March.

Sociedade Brasileira de Radioterapia
Secretary, Dr. Oscar Rocha von Pfuhl, Av. Brigadeiro Luiz Antonio, 644 São Paulo, Brazil. Meets monthly on second Wednesday at 9:00 p.m. in São Paulo at Av. Brigadeiro Luiz Antonio, 644.

Sociedad Colombiana de Radiologia
Secretary, Dr. Luis E. Lozano B., Carrera 12 No. 20–69, 6° piso, Bogota, Colombia. Meets last Thursday of each month.

Sociedad Peruana de Radiologia
Secretary General, Dr. Amador Holgado V. Apartado 2306, Lima, Peru. Meets monthly except during January, February and March, at Asociación Médica Peruana "Daniel A. Carrión," Villalta, 218, Lima.

Sociedad de Radiologica, Cancerologia y Fisica Medica del Uruguay
Secretary, Dr. Arias Bellini, Av. Agraciada 1464, Piso 13, Montevideo, Uruguay.

Continental Europe

Austrian Roentgen Society
President, Dr. Konrad Weiss, Mariannengasse 10, Vienna 9, Austria. Meets second Tuesday of each month in Allgemeine Poliklinik.

Société Belge de Radiologie
General Secretary, Dr. S. Masy, 111 Avenue des Allies, Louvain, Belgium. Meets monthly, second Sunday at Maison des Médecins, Brussels.

Société Française d'Electro-Radiologie Médicale, and its branches: Société du Sud-Ouest, du Littoral Méditerranéen, du Centre et du Lyonnais, de l'Ouest, de l'Est, et d'Alger et d'Afrique du Nord
Secretary-General, Dr. A. Dariaux, 9 bis, Boulevard Rochechouart, Paris IX^e^, France.

Ceskoslovensk společnost pro rëntgenologii a Radiologii v Praze
Secretary, Dr. Roman Bláha, Praha xii, stát. nemocnice, Czechoslovakia. Meets monthly except during July, August, and September. Annual general meeting.

Deutsche Röntgen-Gesellschaft
Secretary, Dr. med. Peter Kröker, Evangelisches Krankenhaus, Huyssens Stiftung, (22a) Essen.

Societa Italiana di Radiologia Medica
Secretary, Prof. Mario Ponzio, Ospedale Mauriziano. Torino, Italy. Meets biannually.

Nederlandse Vereniging voor Electrologie en Roentgenologie
Secretary, Dr. B. J. Rethmeier, Bornsestraat 378, Almelo, Netherlands.

Polish Society of Radiology
Secretary, Dr. Juljusz Borejko, 59 Nowogrodzka St., Warsaw, Poland.

Gdansk Section, Polish Society of Radiology
Secretary, Dr. A. Smigielska, Akademia Lekarska, Gdansk. Meets monthly last Sunday at 10:30, X-Ray Dept., Akademia Gdansk.

Wroclaw Section, Polish Society of Radiology
Secretary, Dr. R. Marciniak, Akad. Medyczna Wroclaw, 68 Curie-Sklodowska St., Wroclaw, Poland. Meets first Sunday of each month, X-Ray Department, Akademia Medyczna Wroclaw.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banual Mărăcine, 30, S.I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad
USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.

Schweizerische Röntgen-Gesellschaft (Société-Suisse de Radiologie)
Secretary, Dr. Max Hopf, Effingerstrasse 47, Bern, Switzerland.

India

Indian Radiological Association
Secretary, Dr. R. F. Sethna, Navsari Building, Hornby Road, Bombay 1, India.

The list of Meetings of Radiological Societies is published in every other issue of the Journal.

PRELIMINARY PROGRAM

FIFTY-SIXTH ANNUAL MEETING OF THE AMERICAN ROENTGEN RAY SOCIETY

THE Fifty-sixth Annual Meeting of the American Roentgen Ray Society will be held at the Palmer House, Chicago, Illinois, September 20 to 23, 1955.

The Executive Council will meet at noon on Sunday, September 18.

The annual Golf Tournament for the Willis F. Manges Trophy for members, and the Exhibitors Trophy for members and guests will be held at the Edgewater Golf Club, and the annual Golf Dinner will be held at the same place after the tournament.

Professor Lester R. Dragstedt will give the Caldwell Lecture on Tuesday evening, September 20. The Annual Banquet will be held on Thursday evening, September 22.

The Instruction Courses will begin at 3:00 P.M. on Tuesday, Wednesday and Thursday, and at 1:30 P.M. on Friday. The detailed plan of the Instruction Courses will be published in the August issue of the JOURNAL.

The Scientific Program, which has been arranged by President-Elect Paul C. Hodges and his Program Committee, is as follows:

Tuesday, September 20, 1955

8:30 A.M. Call to order, Fifty-sixth Annual Meeting, Joshua C. Dickinson, M.D., President.

Address of Welcome: Lawrence A. Kimpton, Chancellor of The University of Chicago, Chicago, Illinois.

Installation of the President-Elect, Paul C. Hodges, M.D., Chicago, Illinois, by President Dickinson and the Chairman of the Executive Council, W. Edward Chamberlain, M.D., Philadelphia, Pennsylvania.

Inaugural Address: President Paul C. Hodges M.D., "Radiology in the Seventh Decade."

9:00 A.M.

New Departures in Diagnostic Radiology
Presiding: Fred J. Hodges, M.D.
Ann Arbor, Mich.

Introduction: Fred J. Hodges, M.D., Ann Arbor, Mich.

Paper
No.

1. Circulatory Dynamics. Carl Wegelius, M.D. (by invitation), Stockholm, Sweden.
2. The Expanding Scope of Cardiovascular Radiology. Melvin M. Figley, M.D. (by invitation), Ann Arbor, Mich.
3. Accomplishments and Possibilities in Cardiovascular Surgery. Henry T. Bahnson, M.D. (by invitation), Baltimore, Md.

Discussion of papers 1, 2 and 3 by Charles T. Dotter, M.D., Portland, Ore.

4. Present Status and Future Promise of Fluoroscopic Image Amplification. Russell H. Morgan, M.D., Baltimore, Md.
5. Electroluminescence and Light Amplifying Phosphors. Ferd E. Williams, Ph.D. (by invitation), Schenectady, N. Y.
6. High Tension Switch-Tube for Radiography. Charles T. Dotter, M.D., Portland, Ore.

Discussion of papers 4, 5 and 6 by W. Edward Chamberlain, M.D., Philadelphia, Pa.

12:30 P.M. Luncheon and Study of Scientific and Technical Exhibits.

12:30 P.M. Luncheon for Faculty of Instruction Courses.

3:00 P.M. Instruction Courses.

4:30 P.M. Executive Business Session of the Society.

Tuesday Evening, September 20, 1955

Eight-Thirty o'Clock
The Caldwell Lecture

"A New Concept of the Etiology of Duodenal and Gastric Ulcer"

by

Lester R. Dragstedt, Ph.D., M.D.
Thomas D. Jones Professor and Chairman of the Department of Surgery of The University of Chicago, Chicago, Illinois

Introduction—Egbert H. Fell, M.D., Chicago, Illinois. Presentation of Medal to Dr. Dragstedt—President Hodges.

Wednesday, September 21, 1955

9:00 A.M.

Symposium: Gastrointestinal Diseases. Presiding: Frederic E. Templeton, M.D., Seattle, Wash.

7. Physiological Considerations in the Problem of Peptic Ulcer. Walter L. Palmer, M.D. (by invitation), Chicago, Ill., and Joseph B. Kirsner, M.D. (by invitation), Chicago, Ill.
8. Radiation in the Therapy of Peptic Ulcer. James W. J. Carpender, M.D., Chicago, Ill., Roscoe E. Miller, M.D. (by invitation), Chicago, Ill., Erwin Levin, M.D. (by invitation), Cleveland, Ohio, and Charles B. Clayman, M.D. (by invitation), Chicago, Ill.
9. Exfoliative Cytology As an Aid in the Differential Diagnosis of Gastric Lesions Discovered by X-Ray. Cyrus Rubin, M.D. (by invitation), Seattle, Wash.
10. The Short-Esophagus Type of Esophageal Hiatal Hernia. Herbert W. Schmidt, M.D. (by invitation), Rochester, Minn.
11. The Lower Esophageal Ring. Richard Schatzki, M.D., Brookline, Mass., and John E. Gary, M.D. (by invitation), Brookline, Mass.
12. Jejunal Interposition in Esophageal Lesions. James F. Nelson, M.D. (by invitation), Seattle, Wash., and Fred J. Hodges, Jr., M.D. (by invitation), Seattle, Wash.
13. The Radiological Diagnosis of Esophageal Varices. Sidney W. Nelson, M.D. (by invitation), Columbus, Ohio.
14. Polyps of the Colon: How to Find Them —Barium Enema, Double Contrast, Fluoroscopic Image Amplification, or What? J. Maurice Robinson, M.D. (by invitation), San Francisco, Calif.

Discussion of papers 7 through 14 by Harry M. Weber, M.D., Rochester, Minn.

12:30 P.M. Luncheon and Study of Scientific and Technical Exhibits.

12:30 P.M. Sixth Annual Past Presidents Luncheon.

3:00 P.M. Instruction Courses.

Thursday, September 22, 1955

9:00 A.M.

Presiding: Traian Leucutia, M.D.
Detroit, Michigan

15. Radioactive Colloidal Gold in the Treatment of Ovarian Carcinoma. H. B. Elkins, M.D., Iowa City, Iowa, and William C. Keettel, M.D. (by invitation), Iowa City, Iowa.

Discussion by Theodore Eberhard, M.D. (by invitation), Philadelphia, Pa.

9:30 A.M.

Symposium: Supervoltage and Megavoltage Radiation Therapy with Various Sources.

16. Results of Treatment of Carcinoma of the Bronchus with 1 Mev. James J. Nickson, M.D. (by invitation), New York, N. Y., and Eugene Cliffton, M.D. (by invitation), New York, N.Y.
17. New Moving Field Cesium 137 Teletherapy Unit. Marshal Brucer, M.D. (by invitation), Oak Ridge, Tenn.
18. Investigation of the Comparative Clinical Usefulness of Telecobalt Therapy Units and 22 Mev. Betatrons in the Treatment of Cancers Infrequently Curable by Conventional Radiotherapy Techniques—Preliminary Report. Gilbert H. Fletcher, M.D. (by invitation), Houston, Texas.
19. Some Observations on the Clinical Effects of Cobalt 60 Telecurie Therapy. C. C. Burkell, M.D. (by invitation), Saskatoon, Saskatchewan, Canada, and T. A. Watson, M. B. (by invitation), Saskatoon, Saskatchewan, Canada.
20. Clinical Aspects of Betatron Irradiation. Roger A. Harvey, M.D., Chicago, Ill., and Lewis L. Haas, M.D. (by invitation), Chicago, Ill.

Discussion of the Symposium by Franz Buschke, M.D. (by invitation), Seattle, Wash., James W. J. Carpender, M.D., Chicago, Ill., William E. Costolow, M.D. (by invitation), Los Angeles, Calif., and Ivan H. Smith, M.D. (by invitation), London, Ontario, Canada.

12:30 P.M. Luncheon and Study of Scientific and Technical Exhibits.

3:00 P.M. Instruction Courses.

4:30 P.M. Executive Business Session of the Society.

Thursday Evening, September 22, 1955

Six-thirty o'Clock
Cocktails—Foyer of Red Lacquer Room
Seven-thirty o'Clock
Annual Banquet—Red Lacquer Room
Presentation of Scientific Awards

Friday, September 23, 1955

9:00 A.M.

21. Investigation of the Principle of Chelation in Contrast Radiography. Robert Shapiro, M.D. (by invitation), New Haven, Conn.
Discussion by Robert J. Hasterlik, M.D. (by invitation), Chicago, Ill.

22. The Tympanic Cavity and Its Ossicles; Roentgen Manifestations in Normal and Abnormal Temporal Bones. Philip J. Hodes, M.D., Philadelphia, Pa., Roderick L. Tondreau, M.D., Philadelphia, Pa., and Harold L. Atkins, M.D. (by invitation), Philadelphia, Pa.
Discussion by John R. Lindsay, M.D. (by invitation), Chicago, Ill.

23. Fluoride Osteosclerosis. Clyde A. Stevenson, M.D., Temple, Texas, and A. Ralph Watson, M.D. (by invitation), Temple, Texas.
Discussion by Paul C. Hodges, M.D., Chicago, Ill.

24. Examination of the Atlanto-Axial Joint Following Injury, with Particular Emphasis on Rotational Subluxation. George Jacobson, M.D., Los Angeles, Calif.
Discussion by Paul C. Hodges, M.D., Chicago, Ill.

25. Primary Pulmonary Vascular Disease in Brothers. E. F. Van Epps, M.D., Iowa City, Iowa.
Discussion by Robert H. Ebert, M.D. (by invitation), Chicago, Ill.

26. Benign Chondroblastoma (Codman's Tumor). Gwilym S. Lodwick, M.D., Iowa City, Iowa, and Lent C. Johnson, M.D. (by invitation), Washington, D. C.
Discussion by C. Howard Hatcher, M.D. (by invitation), Chicago, Ill.

27. Hemosiderosis of the Lung in Patients Having Mitral Commissurotomy. Edwin L. Lame, M.D., Philadelphia, Pa., and James Butcher, M.D. (by invitation), Philadelphia, Pa.
Discussion by Robert H. Ebert, M.D. (by invitation), Chicago, Ill.

12:30 P.M. Luncheon and Study of Scientific and Technical Exhibits.

1:30 P.M. Instruction Courses.

THE ROCKY MOUNTAIN RADIOLOGICAL SOCIETY

The Seventeenth Midsummer Radiological Conference of the Rocky Mountain Radiological Society will be held at the Hotel Shirley-Savoy, Denver, Colorado, On August 18, 19 and 20, 1955. The following are the guest speakers who will participate in the program: Warren W. Furey, M.D., Chicago, Illinois; Higdon B. Elkins, M.D., Iowa City, Iowa; George Z. Williams M.D., Bethesda, Maryland; Isadore Meschan, M.D., Little Rock, Arkansas; John W. Hope, M.D., Philadelphia, Pennsylvania.

The following Scientific Program has been arranged:

Thursday, August 18, 1955

9:00 A.M.–12:00 M. Registration and Addresses of Welcome.

2:00–5:00 P.M. Alfred M. Popma, M.D., President, Rocky Mountain Radiological Society, Presiding.

Semiconductors in the Field of Radiology. E. Dale Trout, Ph.D., Milwaukee, Wis.

The Use of Radioactive Gold Intra-abdominally with Special Reference to Treatment of Carcinoma of the Ovary. Higdon B. Elkins, M.D., Iowa City, Iowa.

Effects of X-ray on the Mechanism of Carcinogenesis in the Liver. George Z. Williams, M.D., Bethesda, Md.

A Review of Cobalt 60 and Its Interstitial Uses. Isadore Meschan, M.D., Little Rock, Ark.

Clinical Stationary Field Therapy with a Cobalt Unit. Part I and II. Gilbert H. Fletcher, M.D., Houston, Texas.

Friday, August 19, 1955

9:00 A.M.–12:30 P.M. Thomas J. Kennedy, M.D., First Vice President, Rocky Mountain Radiological Society, Denver, Colorado, Presiding.

Radiological Demonstration of Tumors of

Sinuses and Nasopharynx. John P. McGraw, M.D., Houston, Texas.

Roentgen Fables of Infants and Children. Part I. The Unfilled Chest, the Bulgy Neck and the Shadowy Belly. John W. Hope, M.D., Philadelphia, Pa.

Neoplasms of the Gallbladder. Ray W. Hammer, M.D., and Thomas J. Kennedy, M.D., Denver, Colo.

A Continuing Problem—Gastric Ulcer. Warren W. Furey, M.D., Chicago, Ill.

Ramifications in the Radiology of the Hand. Isadore Meschan, M.D., Little Rock, Ark.

Some Internal Abdominal Hernias. Cyrus W. Partington, M.D., Denver, Colo.

2:00–5:00 P.M. John H. Freed, M.D., Secretary-Treasurer, Rocky Mountain Radiological Society, Presiding.

Painful Ear Nodules (Winkler's Node or Chronodermatitis Nodularis Chronica Helicis). H. Milton Berg, M.D., Bismarck, N. D.

The Scope and Limitations of Radiology of the Chest. Isadore Meschan, M.D., Little Rock, Ark.

The Treatment of Thyroiditis. Higdon B. Elkins, M.D., Iowa City, Iowa.

Experimental and Therapeutic Studies on Radioactive Gold. George Z. Williams, M. D., Bethesda, Md.

New Concept on Treatment of Breast Cancer. B. V. A. Low-Beer, M.D., San Francisco, Calif.

Saturday, August 20, 1955

9:00 A.M.–12:15 P.M. Alfred M. Popma, M.D., President, Rocky Mountain Radiological Society, Boise, Idaho, Presiding.

Installation of Officers.

Cerebral Angiography in Intracranial Vascular Lesions. Homer G. McClintock, M.D., Denver, Colo.

Translumbar Aortography in Disease of the Aorta. Robert V. Elliott, M.D., Denver, Colo.

Uterosalpingography; Studies in Sterility. Tom M. Fullenlove, M.D., San Francisco, Calif.

X-ray Examination in the Diagnosis of Appendicitis in Children. Anthony F. Rossitto, M.D., Wichita, Kan.

Infantile Cortical Hyperostosis. J. E. Miller, M.D., Dallas, Texas.

Roentgen Fables of Infants and Children. Part II. Brats, Barium and Bowels. John W. Hope, M.D., Philadelphia, Pa.

On Thursday evening there will be an informal guest speakers' dinner at 6 P.M. and at 8 P.M. a joint meeting with the Denver Medical Society.

On Friday evening the banquet will be held, preceded by a social hour.

On Saturday afternoon there will be a trip to Central City with dinner at the Teller House at 6 P.M., and at 8:15 P.M. a play, "St. Joan," by George Bernard Shaw, at the Central City Opera House.

BIOLOGICAL PHOTOGRAPHIC ASSOCIATION

The Twenty-fifth Annual Convention of the Biological Photographic Association will be held at the Hotel Wisconsin, Milwaukee, Wisconsin, on Aug. 30–Sept. 2, 1955, inclusive.

Further information may be obtained from the Convention Chairman, Mr. Leo C. Massopust, Marquette University School of Medicine, 561 North 15th St., Milwaukee 3, Wisconsin.

THIRD INTERNATIONAL COURSE ON TOMOGRAPHY

The Third International Course on Tomography will be held October 3 to 12, 1955, at the Radiology Institute of the University of Genoa, Genoa, Italy, under the direction of Professor Alessandro Vallebona. Conferences, lectures, and communications have been arranged on various phases of tomography. All lectures, while read in the original language, will be simultaneously translated into Italian, French, German, English and Spanish.

In the program the subject of tomography will be treated completely; lectures on theory, geometrical studies, technique and instruments will be given; furthermore, several applications of tomography in the examination of several organs in the normal and the pathological subject will be illustrated; special attention will be drawn to recent progress in the tomographic method.

Scientific communications by members of the course will be accepted. A scientific exhibit and a technical exhibit will be arranged. At the end of the course, members will be given a certificate of attendance.

The entrance fee is 10,000 Italian lira for ordinary members, 6,000 for junior members

(under 30 years of age) and 4,000 for followers, attendants and relatives. Applications and titles of communications should reach the secretary of the course by June 30, 1955. Entrance fees should be sent to the General Secretary, Dr. Luigi Oliva, Instituto di Radiologia, Ospedale S. Martino, Genoa, Italy, or to Cook-Wagon-Lits, General Travel agent for this course. Applicants may ask the same agencies for information concerning travel and hotel reservations.

CHICAGO ROENTGEN SOCIETY

At a recent meeting of the Chicago Roentgen Society the following officers were elected for the year 1955–1956: *President*, Dr. Erich M. Uhlmann, Chicago; *Vice President*, Dr. Irvin F. Hummon, Jr., Chicago; *Secretary-Treasurer*, Dr. R. Burns Lewis, 670 N. Michigan Avenue, Chicago 11, Illinois. Meetings are now held at the Sheraton Hotel the second Thursday in October, November, January, February, March and April at 8 P.M.

FLORIDA RADIOLOGICAL SOCIETY

At the Annual meeting of the Florida Radiological Society the following officers were elected for 1955–1956: *President*, Dr. Hugh G. Reaves, Sarasota, Florida; *Vice President*, Dr. James T. Sheldon, Lakeland, Florida; *Secretary-Treasurer*, Dr. Donald H. Gahagen, 320 Sweet Bldg., Fort Lauderdale, Florida.

GEORGIA RADIOLOGICAL SOCIETY

The Georgia Radiological Society met in conjunction with the annual session of the Medical Association of Georgia at the Bon Air Hotel in Augusta on May 1 and 2, 1955. Dr. Richard H. Chamberlain of the University of Pennsylvania was the guest speaker. The following new officers were elected: *President*, Dr. Neal F. Yeomans, Waycross, Georgia; *Vice President*, Dr. Robert M. Tankesley, Atlanta, Georgia; *Secretary*, Dr. Bert H. Malone, 1406 Reynolds St., Brunswick, Georgia.

INDIANA ROENTGEN SOCIETY

The officers of the Indiana Roentgen Society for the coming year are: *President*, Dr. John A. Ross, Indianapolis, Indiana; *Vice President*, Dr. Jack L. Loudermilk, Fort Wayne, Indiana; *Secretary-Treasurer*, Dr. Chester A. Stayton, Jr., 313 Hume Mansur Bldg., Indianapolis 4, Indiana. Meetings are held twice a year: the first Sunday in May, and during the fall meeting of the Indiana State Medical Association.

MARYLAND RADIOLOGICAL SOCIETY

A meeting of the Maryland Radiological Society was held on May 14, 1955, at the Sheraton-Belvedere Hotel, Baltimore, Maryland, and the following officers were elected: *President*, Dr. Webster H. Brown; *Vice President*, Dr. William Thomas; *Secretary-Treasurer*, Dr. Paul W. Roman, 1810 Eutaw Place, Baltimore 17, Maryland.

PHILADELPHIA ROENTGEN RAY SOCIETY

At the May, 1955, meeting of the Philadelphia Roentgen Ray Society the following officers were elected for the coming year, 1955–1956: *President*, Dr. D. Alan Sampson; *Vice President*, Dr. Edwin L. Lame; *Secretary*, Dr. Herbert M. Stauffer, Temple University Hospital, Philadelphia 40, Pennsylvania; *Treasurer*, Dr. Randal A. Boyer.

RADIOLOGICAL SOCIETY OF NEW JERSEY

At the annual meeting of the Radiological Society of New Jersey, held on April 14, 1955, the following officers were elected for the year 1955–1956; *President*, Dr. Salomon Silvera; *Vice President*, Dr. Carye-Belle Henle; *Secretary*, Dr. George G. Green, 601 Grand Ave., Asbury Park, New Jersey; *Treasurer*, Dr. Leonard Ellenbogen.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

THE DIGESTIVE TRACT IN ROENTGENOLOGY. Volumes I and II. By Jacob Buckstein, M.D., Assistant Professor of Clinical Medicine, Cornell University Medical College; Visiting Roentgenologist (Alimentary Tract Division) Bellevue Hospital, New York City; Attending Gastro-enterologist, Beth David Hospital, New York City, etc. Second edition. Cloth. Price, $30.00. Pp. 1,534, with 897 illustrations. J. B. Lippincott Company, East Washington Square, Philadelphia 5, Pennsylvania, 1953.

In a monograph one always suspects that at one or more points in the text the author will have laid more or less than the due amount of stress on some phases of his subject, so that the book will not prove to be a well balanced consideration of the subject with appropriate emphasis on those sections which merit special attention. This excellent monograph appears to be an exception, meeting the demands of adequate balance of consideration in each of the chapters. The author's long association with a rich clinical and pathologic material has made it possible for him to contribute only well documented case reports, inspiring confidence that he has a broad clinical experience and excellent diagnostic judgment. Sufficient historical comment enables the student to appreciate what great advances have been made in the roentgenology of the digestive tract. Technical problems are discussed whenever necessary. The illustrations are well chosen and beautifully reproduced. This work is commendable as a source book, and should be especially useful to internists, radiologists, and surgeons.

JAMES T. CASE, M.D.

THE RADIOLOGY OF BONES AND JOINTS. By James F. Brailsford, M.D., Ph.D., F.R.C.P., F.I.C.S. (Hon.), Hunterian Professor, Royal College of Surgeons, England, 1934–5, 1943–4; Founder and First President of the British Association of Radiologists (now the Faculty of Radiologists); Emeritus Director of Radiological Studies in Living Anatomy, the University of Birmingham; Consulting Radiologist to the Queen Elizabeth Hospital, Birmingham, the Royal Orthopaedic Hospital, the Accident Hospital and the Warwickshire Orthopaedic Hospital, and other Hospitals of the City; Active Fellow, British Orthopaedic Association, etc. Fifth edition. Cloth. Price, $19.00. Pp. 875, with 725 illustrations. The Williams & Wilkins Company, Baltimore 2, Maryland, 1953.

In his preface to the Fifth Edition of the Radiology of Bones and Joints, the author states that the book has been completely revised to embrace his findings of follow-up investigations of cases throughout the years and those incited by or contained in some 157 recent publications which he has selected for critical study. He has added nearly 200 new illustrations, some being replacements which have more clearly defined features. The book now comprises a digest of his work since he was appointed to the Staff of the Pathological Department of the University of Birmingham, forty-three years ago. It contains 875 pages as compared with 760 in the last previous edition.

As in the previous edition, the book is divided into two parts: The first part of 592 pages deals with the roentgenographic examination of the skeleton from a regional and anatomical standpoint. The second of 236 pages entitled Abnormalities and Pathology of Bones and Joints, General Discussion, is divided into chapters on Developmental Abnormalities and Dystrophies, Generalized Diseases of the Skeleton, Granuloma of Bone, and Bone Tumours. In the preface, the statement is made that the superficial resemblance of clinical, microscopical and radiological features of widely different lesions does not permit of sound teaching by "atlas" methods. Elsewhere in the chapter on Bone Tumours the author states that the atlas is excellent for constant features such as found in normal histology, but in any sphere with infinite variety, pathology or radiology, it can be misleading. One obvious disadvantage of the division of the subject matter of the book is that when reading the second part on Abnormalities and Pathology of Bones and Joints, one is forced to turn back to several or more pages in the first portion to obtain roentgeno-

grams of the condition illustrated under the various regional headings.

Dr. Brailsford's opinion on the too frequent resort to biopsy is well known and, as in previous editions, he discusses this question at length in the chapter on Bone Tumours under the headings of Radiographic Interpretation, and Biopsy. He believes that advantage is not taken of the sound teachings of clinicians and pathologists if every patient is submitted to surgical exploration. The summation of reports from many sources on relatively limited knowledge does not add up to accuracy. Furthermore, he states that it has been clearly shown that it is sometimes possible, given adequate knowledge, to determine accurately the nature of the lesions merely from a study of the roentgenographic appearances. The most valuable contribution is made by biopsy, he feels, when its findings indicate simplicity and prevent the unnecessary amputation of a limb rather than when it confirms the clinical and/or radiographic evidence of malignancy. Throughout the book the radiological features of a given condition are emphasized, often in great detail.

The book covers all common and many rare diseases and syndromes of bones and joints. Much personal experience of the author is related. The extensive bibliography covering seventeen pages reflects the study which the author has made in the preparation of this new volume. However, a minor defect is the lack of a uniform arrangement of the various references, sometimes with omission of volume or page numbers. The reproductions of roentgenograms are of excellent quality. Previous editions have been found very valuable by radiologists and clinicians interested in diseases of the skeleton and it can be predicted that this edition will be even more deserving of a place in their libraries.

Ralph S. Bromer, M.D.

The Fundamentals of X-ray and Radium Physics. By Joseph Selman, B.S., M.D., Director, School for X-ray Technicians, Tyler Junior College; Chief of Radiology, Mother Frances Hospital; Director, Radiology Department, Medical Center Hospital; Consultant in Radiology, East Texas Tuberculosis Hospital, Tyler, Texas. Cloth. Price, $8.50. Pp. 340, with 174 illustrations. Charles C Thomas, Publisher, 301 East Lawrence Avenue, Springfield, Illinois, 1954.

This textbook in radiological physics is primarily designed for diagnostic roentgen-ray technicians and also as an introductory text for residents in diagnostic roentgenology. The subjects of this field are covered in 22 chapters.

Chapter 1 is devoted to simplified mathematics and is a detailed and clear presentation of elementary concepts in algebra, geometry, and the significance of graphs. Chapters 2 through 8 contain discussions of units, electricity and magnetism, and related elementary concepts in physics. Numerous illustrations are provided. Chapter 9 contains a description of motors and generators and defines such concepts as effective voltage, impedance, and capacitive and inductive reactance.

Chapter 10 is devoted to transformers and autotransformers. The function of the autotransformer is compared to the rheostat. An understanding of the operation of these units is important and the presentation is particularly lucid. Methods of rectifying alternating current are described in Chapter 11 and various types of rectifier circuits are diagrammed. Factors which control the output of roentgen tubes are described in Chapter 12, along with the properties of roentgen rays and features of their absorption by matter. In Chapter 13, details of the construction of roentgen tubes and rectifier valve tubes are outlined and important features, such as the heat storage capacity of the anode, are included. In Chapter 14, various roentgen generator circuits are explained and their components described. A typical control panel is illustrated along with its operation. Chapters 15, 16 and 17 are devoted to dark room construction features, accessory equipment, and the use of intensifying screens with film. Some discussion of the chemistry of films is included and also a helpful identification of various types of errors in film handling and development. In Chapter 18 the quality of films is discussed together with an explanation of distortion, magnification, etc. The influence of focal spot size, anode film distance, etc., on resolution is explained. A chapter on the use of grids, diaphragms and cone filters to improve the quality of film follows. Special procedures, such as stereoscopic roentgenography, are treated in Chapter 20. Chapter 21 is a brief discussion of radium and some of its properties, and the conventional containers in which it is customarily used. Chapter 22 treats the important subject of protection, the concept of permissible dose, and provides many helpful de-

tails in the application of protection considerations to practical situations. Each of the chapters is followed with several pertinent questions. Some properties of radioactive isotopes are briefly discussed in an appendix. A bibliography and index follow.

This text is well written and is obviously the result of considerable pedagogical experience. A desirable amount of deliberate repetition is employed to clarify the presentation of ideas. Numerous drawings are provided for the same purpose.

JOHN S. LAUGHLIN

PHYSICAL ASPECTS OF BETATRON THERAPY. By John S. Laughlin, Associate Professor of Biophysics, Cornell University Medical College, Sloan-Kettering Division and Department of Physics, Memorial Center for Cancer and Allied Diseases, New York City. Fabrikoid. Pp. 98, with 34 illustrations and 11 tables. Charles C Thomas, Publisher. 301 East Lawrence Avenue, Springfield, Illinois, 1954.

This 98 page monograph describes the physical basis for the therapeutic use of multimillion volt roentgen-ray and electron beams such as those available from the betatron, synchrotron, and electron linear accelerator. The book is divided into two sections, one devoted to high energy roentgen rays, particularly in the energy range of 22 mev. (peak). The other section is on the direct electron beam at energies of 5 to 22 mev.

Subjects discussed are the collimation of the beam, shielding of the machine to protect the patient from stray radiation, multifield therapy and the isodose distributions obtained in typical applications, the apparatus for measurement and the calculation of the dose delivered, and the relative biological effectiveness of the beams compared to 200 kev. roentgen rays. A large number of references is given.

Multimillion volt roentgen rays and electrons, due to their superior depth dose characteristics, will find increasing use in the near future. This book is the only one written on the physics behind the therapeutic use of these machines. Workers who are setting up facilities for multimillion volt therapy will find it invaluable.

H. O. ANGER

BOOKS RECEIVED

THE DIGESTIVE TRACT IN ROENTGENOLOGY. Volumes I and II. By Jacob Buckstein, M.D., Assistant Professor of Clinical Medicine, Cornell University Medical College; Visiting Roentgenologist (Alimentary Tract Division), Bellevue Hospital, New York City; Attending Gastro-enterologist, Beth David Hospital, New York City, etc. Second edition. Cloth. Price, $30.00. Pp. 1,534, with 897 illustrations. J. B. Lippincott Company, East Washington Square, Philadelphia 5, Pennsylvania, 1953.

RADIOLOGIE CLINIQUE DE L'INTESTIN GRÊLE; DE L'ADULTE ET DE L'ENFANT (OCCLUSION AIGUË DE L'ADULTE EXCEPTÉE). Par P. Porcher, Membre de l'Académie de Chirurgie, Radiologiste des Hôpitaux de Paris; P. Buffard, Radiologiste des Hôpitaux de Lyon; J. Sauvegrain, Radiologiste des Hôpitaux de Paris. Paper. Price 5000 fr. Pp. 614, with 350 illustrations. Masson et Cie, 120, boulevard Saint-Germain, Paris 6, France, 1954.

THE RADIOLOGY OF BONES AND JOINTS. By James F. Brailsford, M.D., Ph.D., F.R.C.P., F.I.C.S. (Hon.), Hunterian Professor, Royal College of Surgeons, England, 1934–5, 1943–4; Founder and First President of the British Association of Radiologists (now the Faculty of Radiologists); Emeritus Director of Radiological Studies in Living Anatomy, the University of Birmingham; Consulting Radiologist to the Queen Elizabeth Hospital, Birmingham, the Royal Orthopaedic Hospital, the Accident Hospital and the Warwickshire Orthopaedic Hospital, and other Hospitals of the City; Active Fellow, British Orthopaedic Association, etc. Fifth Edition. Cloth. Price, $19.00. Pp. 875, with 725 illustrations. The Williams & Wilkins Company, Baltimore 2, Maryland, 1953.

CONGENITAL HEART DISEASE; AN ILLUSTRATED DIAGNOSTIC APPROACH. By Henry S. Kaplan, M.D., Professor of Radiology, Stanford University School of Medicine; and Saul J. Robinson, M.D., Assistant Clinical Professor of Pediatrics, Stanford University School of Medicine; Chief, Department of Pediatrics, Mount Zion Hospital, San Francisco. Cloth. Price, $12.50. Pp. 126, with 146 illustrations. McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York 36, New York, 1954.

BASES DE L'INTERPRÉTATION RADIOLOGIQUE; RADIOGÉOMÉTRIE. Two volumes. Par Manoel de Abreu, Professeur à la Faculté des Sciences Médicales de Rio de Janeiro. Cloth. Price, Bronchés, 5.000 fr.; Cartonnés toile, 6.2000 fr. I. Texte. Pp. 214; II. Iconographie. Pp. 312, with 683 figures, plus 82 plates. Masson et Cie, 120, boulevard Saint-Germain, Paris 6, France, 1954.

The Central Veins and Deep Dural Sinuses of the Brain. Acta radiologica, Supplement 107. By Curt Johanson. Paper. Price, Sw. Kr. 25:-. Pp. 184, with 91 illustrations. Acta radiologica, Stockholm 2, Sweden, 1954.

Planning Guide for Radiologic Installations. By the Committee on Planning of Radiologic Installations of the Commission on Public Relations of the American College of Radiology. Wendell G. Scott, M.D., Chairman. Cloth. Price, $8.00. Pp. 336, with numerous illustrations and tables. Year Book Publishers, Inc., 200 E. Illinois Street, Chicago 11, Illinois, 1953.

Physiology of the Eye; Clinical Application. By Francis Heed Adler, M.A., M.D., F.A.C.S., Professor of Ophthalmology, School of Medicine, University of Pennsylvania, and Consulting Surgeon, Wills Hospital, Philadelphia. Second edition. Cloth. Price, $13.00. Pp. 724, with 329 illustrations. C. V. Mosby Company, 3207, Washington Boulevard, St. Louis 3, Missouri, 1953.

Transactions of the American Ophthalmological Society. Volume LI. Eighty-ninth Annual Meeting, Hot Springs, Virginia, 1953. Cloth. Price, $18.00. Pp. 793, with numerous illustrations. Columbia University Press, 2960 Broadway, New York 27, New York, 1954.

Manual of Clinical Mycology. By Norman F. Conant, Ph.D., Professor of Mycology and Associate Professor of Bacteriology, Duke University School of Medicine; David Tillerson Smith, M.D., Professor of Bacteriology and Associate Professor of Medicine, Duke University School of Medicine; Roger Denio Baker, M.D., Chief, Laboratory Service, Veterans Administration Hospital, Durham, N. C.; Jasper Lamar Callaway, M.D., Professor of Dermatology and Syphilology, Duke University; Donald Stover Martin, M.D., Chief, Bacteriology Section, Communicable Diseases Center, Chamblee, Georgia. Second edition. Cloth. Price, $6.50. Pp. 456, with 202 illustrations. W. B. Saunders Company, Washington Square, Philadelphia 5, Pennsylvania, 1954.

The Mechanism of Inflammation; An International Symposium. Edited by G. Jasmin, M.D., and A. Robert, M.D., Institut de Médecine et de Chirurgie Expérimentales, Université de Montréal. Cloth. Pp. 308, with illustrations. Acta, Inc., 5465 Decarie Boulevard, Montreal 29, Quebec, Canada, 1953.

Annual Review of Medicine. Volume 5. Windsor C. Cutting, Editor, Stanford University School of Medicine; Henry W. Newman, Associate Editor, Stanford University School of Medicine. Cloth. Price, $7.00. Pp. 452. Annual Reviews, Inc., Stanford, California, 1954.

Seventy-Five Years of Medical Progress, 1878–1953. Edited by Louis H. Bauer, M.D., F.A.C.P., Secretary-General, The World Medical Association; Past President, The World Medical Association. Cloth. Price, $4.00. Pp. 286, with illustrations. Lea & Febiger, Washington Square, Philadelphia 6, Pennsylvania, 1954.

The Fundamentals of X-ray and Radium Physics. By Joseph Selman, B.S., M.D., Director School for X-ray Technicians, Tyler Junior College; Chief of Radiology, Mother Frances Hospital, Director, Radiology Department, Medical Center Hospital; Consultant in Radiology, East Texas Tuberculosis Hospital, Tyler, Texas. Cloth. Price, $8.50. Pp. 340, with 174 illustrations. Charles C Thomas, Publisher, 301 East Lawrence Avenue, Springfield, Illinois, 1954.

Physical Aspects of Betatron Therapy. By John S. Laughlin, Associate Professor of Biophysics, Cornell University Medical College, Sloan-Kettering Division and Department of Physics, Memorial Center for Cancer and Allied Diseases, New York City. Fabrikoid. Pp. 98, with 34 illustrations and 11 tables. Charles C Thomas, Publisher, 301 East Lawrence Avenue, Springfield, Illinois, 1954.

Atomic Medicine. Edited by Charles F. Behrens, M.D., Rear Admiral, MC., U. S. Navy, Staff Medical Officer, Eastern Sea Frontier; Formerly: Director, Atomic Defense Division, Bureau of Medicine and Surgery, Navy Department; Commanding Officer, Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland. Second edition. Cloth. Price, $11.00. Pp. 632, with numerous illustrations. The Williams & Wilkins Company, Mt. Royal and Guilford Avenues, Baltimore 2, Maryland, 1953.

Biological Hazards of Atomic Energy; Being the papers read at the Conference convened by the Institute of Biology and the Atomic Scientists' Association, October 1950. Edited by A. Haddow. Cloth. Price, $8.00. Pp. 235, with numerous illustrations. Oxford University Press, 114 Fifth Avenue, New York 11, New York, 1953.

ABSTRACTS OF RADIOLOGICAL LITERATURE

Department Editor: T. Leucutia, M.D., Harper Hospital, Detroit 1, Michigan

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Abdomen

Hodgson, J. R., and Kennedy, R. J. L.: Bleeding lesions of the gastrointestinal tract in infants and children 160

Barden, S. P.: Ileo-ileal intussusception in a child; a case report 161

Hornsby, A. T., and Baylin, G. J.: Sprue vs. pancreatogenous steatorrhea; an evaluation of the small bowel study as an aid in differentiation 161

Astley, R., and Gerrard, J. W.: The x-ray diagnosis of coeliac disease 161

Gynecology and Obstetrics

Haas, R. L., Latourette, H. B., and Whitehouse, W. M.: Clinical applications of obstetric radiology 162

Rozin, S.: The diagnosis of tubointestinal and tubovesical fistulas by hysterosalpingography 163

Alpert, M., and Lecher, B. D.: Opacification of a calcified leiomyoma during hysterosalpingography 163

Genitourinary System

Dick, D. R., *et al.*: The use of a short acting, muscle relaxant drug (succinylcholine chloride) in diagnostic urography: a preliminary report 163

Idbohrn, H.: Renal angiography in cases of delayed excretion in intravenous urography .. 163

Truscott, D. E.: The radiological control of kidney injuries 164

Keshishian, J. M., and Spencer, W. A.: Visualization of the inferior vena cava as an adjunct to diagnosis of retroperitoneal tumors, a case report 164

Comarr, A. E.: Renal changes in paraplegia as screened by routine excretory urography ... 165

Wilhelm, S. F.: Gas insufflation through the lumbar and presacral routes 165

Weens, H. S., and Florence, T. J.: The diagnosis of hydronephrosis by percutaneous renal puncture 165

Garrett, R. A., Norris, M. S., and Vellios, F.: Renal papillary necrosis: a clinicopathologic study 165

Nervous System

Chambers, W. R.: Diastematomyelia; report of a case diagnosed preoperatively 166

Skeletal System

O'Rahilly, R.: A survey of carpal and tarsal anomalies 166

Stewart, M. J.: Fractures of the carpal navicular (scaphoid); a report of 436 cases 167

Knickerbocker, T. W., and Reilly, R.: Traumatic epidermoid cyst of the terminal phalanx 168

Stiepan, F. E.: Giant-cell tumor of the head of the humerus; with a case report 168

Ford, L. T., and Key, J. A.: The differential diagnosis of shoulder, upper back and neck pain and the conservative treatment of cervical disc lesions 168

James, J. I. P.: Scoliosis in children 168

Compere, E. L., Johnson, W. E., and Coventry, M. B.: Vertebra plana (Calvé's disease) due to eosinophilic granuloma 169

Cleveland, M., and Fielding, J. W.: A continuing end-result study of intracapsular fracture of the neck of the femur 169

Carr, C. R., Berley, F. V., and Davis, W. C.: Pigmented villonodular synovitis of the hip joint; case report 170

Fawcitt, J.: The radiological pattern of pseudocoxalgia 170

Urist, M. R., Mazet, R., Jr., and McLean, F. C.: The pathogenesis and treatment of delayed union and non-union; a survey of eighty-five ununited fractures of the shaft of the tibia and one hundred control cases with similar injuries 170

Wellens, P., and Jansen, W.: Considerations on the osseous lesions of Hodgkin's disease . 171

Komins, C.: Familial metaphyseal dysplasia (Pyle's disease) 172

Baker, S. L.: General softening of bone due to metabolic causes. I. The histopathology of porotic and malacic conditions of bone 172

Dent, C. E., and Hodson, C. J.: Generalised softening of bone due to metabolic causes. II. Radiological changes associated with certain metabolic bone diseases 172

Teall, C. G.: Generalised softening of bone due to metabolic causes. III. Some observations on the radiology of Lignac-Fanconi disease and renal infantilism 173

Swann, G. F.: Generalised softening of bone due to metabolic causes. IV. Pathogenesis of bone lesions in neurofibromatosis..... 173
Gimes, B., and Szendröi, Z.; On the significance of the shifts in the serum protein fractions for the diagnosis of bone tumors..... 173

Blood and Lymph System

Wetzel, N.: Retrograde filling of the carotid system following vertebral angiography.... 174
Aubaniac, R., *et al.*: Angiocardiography by the infraclavicular route; comparison with other methods of injection..... 174
Jordan, A., *et al.*: Unsuspected superior vena caval obstruction detected by angiocardiography; report of a case..... 174
Gyllenswärd, Å., and Lodin, H.: The value of selective angiocardiography in the diagnosis of complete transposition of the great vessels..... 174
Taveras, J. M., Mount, L. A., and Friedenberg, R. M.: Arteriographic demonstration of external-internal carotid anastomosis through the ophthalmic arteries..... 175
Willis, G. C., Light, A. W., and Gow, W. S.: Serial arteriography in atherosclerosis..... 175
Gould, D. M., and Willson, J. K. V.: Abdominal aortography..... 175
Wachtler, F.: Roentgenologic findings in hemangiomas of the striated muscles..... 176

General

Hilbish, T. F.: Developments in diagnostic radiology..... 176

RADIATION THERAPY

Paterson, R., and Paterson, Edith: Hodgkin's disease..... 177
Scholte, P. J. L., Kok-v. Alphen, C. C., and Combée, R.: Treatment of the cornea with a new Lilliput roentgen tube..... 177
Windeyer, B. W.: Cancer of the thyroid and radiotherapy; Mackenzie Davidson Memorial Lecture..... 178
Boyd, D. P., *et al.*: Carcinoma of the lung; a report of 403 cases..... 179
Larsson, L.-G., and Mortensson, G.: Carcinoma of the paranasal sinuses and the nasal cavities; a clinical study of 379 cases treated at Radiumhemmet and the Otolaryngologic Department of Karolinska Sjukhuset, 1940–1950..... 179
White, G., Sieniewicz, J., and Christensen, W. R.: Improved control of advanced oral cancer with massive roentgen therapy..... 180

RADIOISOTOPES

Seed, L., and Jaffe, Bertha: Comparison of the tracer dose and the therapeutic dose of I^{131} as to thyroid uptake, effective half-life, and roentgen dosage..... 180
Lindsay, S., Dailey, M. E., and Jones, M. D.: Histologic effects of various types of ionizing radiation on normal and hyperplastic human thyroid glands..... 181
Allen, W. M., Sherman, A. I., and Arneson, A. N.: Carcinoma of the cervix; results obtained from the irradiation of the parametrium with radioactive colloidal gold..... 181
Mellink, J. H.: A 20 curie telecobalt unit... 181
Shoch, D., and Puntenney, I.: Ionizing radiation cataracts..... 182
Davis, A. K., Alpen, E. L., and Sheline, G. E.: The combined effects of thermal burns and whole-body x irradiation. II. Anemia... 182
Tullis, J. L., Lamson, B. G., and Madden, S. C.: Pathology of swine exposed to total body gamma radiation from an atomic bomb source..... 183
Sinclair, W. K., Trott, N. G., and Belcher, E. H.: The measurement of radioactive samples for clinical use..... 183
Greer, M. A., and Smith, G. E.: Method for increasing the accuracy of the radioiodine uptake as a test for thyroid function by the use of desiccated thyroid..... 184
Hunzinger, W. A., Willenegger, H., and Meier, A. L.: Blood volume determinations with I^{131} albumin after infusion of plasma substitutes..... 184
Seidlin, S. M., Yalow, A. A., and Siegel, E.: Blood radiation dose during radioiodine therapy of metastatic thyroid carcinoma... 185
Pochin, E. E., Cunningham, R. M., and Hilton, Gwen: Quantitative measurements of radioiodine retention in thyroid carcinoma..... 185
Engfeldt, B., *et al.*: A preliminary study of the in vivo and in vitro uptake of Sr^{90} in bone tissue and the osseous localization of radioactive fission products from atomic explosions..... 186
Lang, N., Schettler, G., and Wildhack, R.: A case of "agammaglobulinemia" and the behavior of parenterally administered radioactive gamma-globulin in the serum..... 186
Bauer, R. E., Moss, I. H., and Richardson, A. D.: A study of radioactive phosphorus activities in pleural effusions..... 186
Blocker, T. G., Jr., *et al.*: The use of radioactive sulphur labeled methionine in the study of protein catabolism in burn patients. 187

CHEMOTHERAPY

Houghton, L. E., Walter, J. B., and Jones, D. E. A.: The inhibition of acute x-ray damage by cortisone..... 187
Evans, J. A., and Steinberg, I.: Pulmonary complications of ACTH and cortisone; roentgen observations..... 187

Burchenal, J. H., *et al.*: Clinical evaluation of 6-mercaptopurine in the treatment of leukemia 187

MISCELLANEOUS

Hurst, G. S., and Ritchie, R. H.: Fast neutron dosimetry 188
Whitcher, S. L., and Todd, N.: The x-ray absorption coefficients for a borosilicate glass 188
Wang, T. J.: Calibration of therapeutic x-ray generators 188
Abel, M. S.: Body-section radiography with an ultra-fine focal spot tube utilizing variable magnification for plane selectivity 188
Ponseti, I. V., with the assistance of Shepard, R. S.: Lesions of the skeleton and of other mesodermal tissues in rats fed sweet-pea (*lathyrus odoratus*) seeds 189
Furth, J., *et al.*: Some late effects in mice of ionizing radiation from an experimental nuclear detonation 189
Bruce, W. R., and Johns, H. E.: Investigation of grid fields with a miniature ionization chamber 189
Schoen, D., and Magnus, H. E.: Moving field irradiation through a lead grid 190
Rigler, L. G., and Watson, J. C.: A combination film changer for rapid or conventional radiography 190
Shellabarger, C. J., and Godwin, J. T.: Studies on the thyroidal uptake of astatine in the rat 191
Hamilton, J. G., Durbin, Patricia W., and Parrott, M.: The accumulation and destructive action of astatine^{211} (eka-iodine) in the thyroid gland of rats and monkeys 191
Duff, G. L., McMillan, G. C., and Lautsch, Elizabeth V.: The uptake of colloidal thorium dioxide by the arterial lesions of cholesterol atherosclerosis in the rabbit; its significance in relation to pathogenesis 192
Daniel, P. M., Prichard, Marjorie M. L., and Ward-McQuaid, J. N.: An angiographic study of the renal circulation in experimental hypertension in the dog 192
Sapeika, N.: Lead EDTA complex; further radiographic studies 193
Arnulf, G., *et al.*: Experimental and clinical results with lymphography 193
Parker, H. M.: Symposium on radiation units. Radiation units and radiation instruments 193
Focht, Elizabeth F.: Symposium on radiation units. Surface dose 194

ROENTGEN DIAGNOSIS

Abdomen

Hodgson, John R., and Kennedy, Roger L. J. Bleeding lesions of the gastrointestinal tract in infants and children. *Radiology*, Oct., 1954, *63*, 535–541.

Since bleeding from the alimentary tract is an important manifestation of significant disease, the case records and roentgenograms of all infants and children seen at the Mayo Clinic in a five year period with gastrointestinal conditions that might cause gross bleeding were reviewed. All cases of bleeding from hemorrhoids, anal fissure and anal abrasion, as well as from the nose and mouth, were excluded. Only those cases in which gross blood was present were studied.

A group of 246 cases were found and the causes of bleeding are listed in the following table:

	Total	Age in Years		
		Group I Under 2	Group II 2–6	Group III 7–15
Chronic ulcerative colitis	94	1	12	81
Polyps of colon	40	—	31	9
Cause undetermined	19	4	10	5
Meckel's diverticulum	17	6	8	3
Intussusception	17	14	3	—
Varices of esophagus	10	—	4	6
Duodenal ulcer	8	—	4	4
Blood dyscrasias	11	3	4	4
Mesenteric lymphadenitis	5	—	4	1
Volvulus	6	5	1	—
Regional enteritis	5	—	1	4
Jejunal polyps	1	—	—	1
Gastric ulcer	1	1	—	—
Gastroenteritis	2	1	1	—
Lymphosarcoma of ileum	1	—	—	1
Foreign body in esophagus	1	1	—	—
Meningitis	2	2	—	—
Hemorrhagic disease of newborn	2	2	—	—
Carcinoma of rectosigmoid	1	—	—	1
Acute enteritis	2	—	2	—
Ileal band	1	1	—	—
Total	246	41	85	120

As certain differences in the etiology of hemorrhage are apparent among children of various ages, the causes were classified on an age basis into 3 groups as is seen in the table. The most common cause of bleeding in Group I (less than 2 years) was intussusception with 14 cases, followed by Meckel's diverticulum and volvulus with 6 and 5 cases each respectively. The other less common causes are noted in the table. In 4 cases the cause of bleeding could not be found.

In Group II (2 through 6 years) the most common source of bleeding was polyps of the colon with 31 cases out of 85 (37 per cent) being due to this cause. Chronic ulcerative colitis was next with 14 per cent. In 12 per cent of the cases no cause could be found by roentgen studies. Meckel's diverticulum as a cause was found in a little less than 10 per cent. Diagnosis of this condition, as in the infants, was made by exploration, as roentgen demonstration and diagnosis is not very successful. Other less frequent causes are listed in the table. Duodenal ulcer is difficult to demonstrate because of inability to obtain adequate distention of the cap. The diagnosis of mesenteric lymphadenitis was made by exploration in all cases when the site of bleeding could not be determined by roentgenographic measures. This diagnosis, however, is not satisfactory as an explanation for bleeding. Esophageal varices are more easily demonstrated when the varices have been present for some time.

Chronic ulcerative colitis was the most common cause of bleeding in the children in Group III, it being present in 67 per cent of the cases. The roentgen diagnosis is not difficult when the condition is moderately or far advanced as the narrowing, shortening and thickening of the intestine are obvious.

Early recognition of the minor unusual pattern alternations are best seen on good post-evacuation roentgenograms. Polyps of the colon were next in frequency, but consisted of only 7.5 per cent. Their demonstration was directly dependent on the thoroughness and completeness of the colon preparation for double contrast studies. Esophageal varices were more easily demonstrated in this age group and they accounted for 6 per cent of the cases in this group. Duodenal ulcers were also more easily demonstrated and, as with regional enteritis, closely resembled the roentgen findings as seen in adults. The cause of bleeding was not determined in 4 per cent.

Of 9 cases of neoplastic disease of the large and small intestine found in the review of these cases, only 2 gave a history of bleeding as noted in the table. No instance of ulcerated benign intestinal tumor was found.—*Donald N. Dysart, M.D.*

Barden, Stuart P. Ileo-ileal intussusception in a child; a case report. *Radiology*, Oct., 1954, *63*, 542–543.

A case of ileo-ileal intussusception in a two year old girl is reported. The diagnosis of intussusception was suspected from the history and physical examination.

Barium enema examination was performed showing an entirely normal colon and a visualized appendix. After introduction of a small amount of air, reflux of barium into the terminal ileum revealed the cup-shaped deformity of intussusception in relation to the palpable mass.

Surgery was performed, consisting of resection of the gangrenous segment of the small intestine. A Meckel's diverticulum was found to have been the origin of the process.—*Donald N. Dysart, M.D.*

Hornsby, Aubrey T., and Baylin, George J. Sprue vs. pancreatogenous steatorrhea; an evaluation of the small bowel study as an aid in differentiation. *Radiology*, Oct., 1954, *63*, 491–497.

Two leading causes for steatorrhea are sprue and pancreatic intestinal enzyme deficiency. Three basic classification of steatorrhea are generally acepted:

(a) Idiopathic, as seen in sprue and severe deficiency states.

(b) Pancreatogenous, resulting from a deficiency of pancreatic intestinal enzyme. Intrinsic inflammatory or neoplastic disease, duct obstruction, and extirpative surgery are the chief causes.

(c) Symptomatic, the result of obstruction of small bowel lacteals by neoplastic or inflammatory processes. This group includes amyloid disease, lymphoma, Whipple's disease, regional enteritis, and others.

The authors studied 19 cases of sprue and 10 cases of pancreatogenous steatorrhea in an attempt to see if there were any sufficiently characteristic roentgen findings that would suggest one or the other disease. All of these patients had steatorrhea at the time of small bowel evaluation.

Absolute difference noted in 3 sprue cases was a sufficiently generalized atony to simulate a paralytic ileus. Nothing resembling this was found in any case of pancreatogenous steatorrhea. Relative differences include the moulage sign of Kantor. The moulage was unmistakenly present in 15 of 19 sprue cases, equivocal in 1, and absent in 3. It was unequivocally absent in 8 of the 10 cases of pancreatogenous steatorrhea, equivocal in 2, and definitely present in none. Coarse folds and flocculation were on the whole more frequent and pronounced in the sprue patients. There was no difference in the transit time in all cases.

The authors conclude that the closer the small bowel pattern approaches the normal, the more likely it is that the steatorrhea is of pancreatogenous origin. They state, however, that since a certain percentage of active sprue cases will have a normal small bowel pattern, and that an occasional pancreatogenous steatorrhea will result in a severe deficiency state, the application of these observations to the individual patient, as a basis for differentiation, may lead to an erroneous diagnosis.—*Donald N. Dysart, M.D.*

Astley, R., and Gerrard, J. W. The x-ray diagnosis of coeliac disease. *Brit. J. Radiol.*, Sept., 1954, *27*, 484–490.

Much of the modern conception of the behavior of barium sulphate suspensions in the small intestine dates from the work of Frazer, French and Thompson (1949). Previously, it had been a general belief that the contrast medium faithfully recorded the shape of the lumen of the bowel. Thus, in the so-called "deficiency pattern," it was considered that segments of dilated bowel with deficient or altered mucosal folds were interspersed with segments that were narrowed or spastic. Frazer and his colleagues, however, were able to induce similar changes in normal subjects by giving a variety of substances in addition to simple aqueous barium sulphate suspension. Among these substances were fatty acids and hypertonic solutions of sodium chloride, sodium bicarbonate and glucose. Corresponding studies were made in vitro and it was found that alimentary mucus was a potent cause of clumping. When a simple barium sulphate suspension was mixed with mucus and an autopsy specimen of the small intestine clumping could be demonstrated roentgenographically, the pattern obtained bore no relationship to the true shape of the bowel and could not be due to the presence of alternating segments of spasm and dilatation. From this it was suggested that hypertonic solutions and fatty acid induced clumping by stimulating the production of excessive mucus in the small intestine and that a

similar excess also occurred in steatorrheas such as the sprue syndrome.

Ardran, French and Mucklow, 1950, then found that certain complex barium sulphate suspensions, resisted the clumping effect of alimentary mucus. In subjects with idiopathic steatorrhea simple aqueous suspensions gave a discontinuous pattern with failure to represent true structural detail, whereas the complex suspensions gave a continuous pattern with good mucosal detail. Similar findings were obtained in celiac disease by Astley and French, 1951, who also emphasized the general advantages of the complex mucus resistant suspensions in minimizing the clumping that occurs as a normal phenomenon in infancy and early childhood.

The present study was undertaken in an attempt to determine whether small intestinal dilatation or the clumping of a barium sulphate suspension was the more useful diagnostic sign in celiac disease. Thirty children with celiac disease were examined with ages ranging from 4½ to 14 years and three older children, ages 15 and 19 years. The previous duration of the disease varied from 3½ to 15 years.

Thirty-seven normal children were also examined, 2 were infants and the ages of the remainder ranged from 3 to 13 years. Two contrast media were used, one was a simple twenty-five per cent weight volume suspension of barium sulphate and water made from barium sulphate paste and containing no suspending agents. The complex suspension was a commercial preparation, Novumbrose, previously shown to resist the clumping effects of alimentary mucus. It was diluted with water to contain 50 per cent w/v of barium sulphate.

The normal children were examined with a simple barium sulphate suspension only, and children with celiac disease were examined twice using both contrast media. One to three fluid ounces of barium sulphate suspension according to the child's size were used for each meal.

Results: A. Normal children. The children under 5 years of age all showed clumping of the simple suspension, and in all but one the clumping was gross.

B. Celiac disease. Simple suspension: about half of the children gave gross clumping and the other half gave intermediate degrees of clumping. Mucus resistant preparation: 22 of the 32 children showed definite small intestinal dilatation; it was gross in 6, considerable in 10 and slight in 6 and there were 8 borderline cases.

C. Comparison of the two contrast media in celiac disease. Of the 8 children with indefinite small intestinal dilatation, one child showed gross clumping of the simple suspension and 7 intermediate degrees of clumping. Of the 15 children with intermediate degrees of clumping of the simple suspension, 8 showed definite small intestinal dilatation; dilatation was borderline in 7.

The conclusion is reached that up to the age of 14 years clumping of simple aqueous barium sulphate solutions is so frequent in normal children that it has little diagnostic significance. Using a mucus resistant preparation, however, there is a reasonably high incidence of definitely abnormal roentgen findings in the children with celiac disease. The presence of small intestinal dilatation in the acute phase of celiac disease has been reported previously. It is now shown that even the later stages of the diseases will show dilatation in a significant proportion.—*Arthur B. Smith, M.D.*

Gynecology and Obstetrics

Haas, R. L., Latourette, H. B., and Whitehouse, W. M. Clinical applications of obstetric radiology. *Surg., Gynec. & Obst.*, Oct., 1954, *99*, 462–468.

The literature is replete with articles concerning some phases of obstetric radiology. However, the authors point out that there has been relatively little accomplished toward clinical integration of the two specialties of radiology and obstetrics. The material presented in the article originated in the obstetric radiology conferences conducted at the University of Michigan Hospital. These conferences were held weekly and were attended by the radiologist, obstetrician, residents and medical students. It was felt that the radiologist gained insight into the problems faced by the obstetrician, and vice versa.

Roentgenographic examination of obstetrical patients is ordinarily carried out without special equipment. The authors have ascertained that routine examination is not dangerous to the fetus and that the fetus probably receives not more than one roentgen total.

A simple routine study has been evolved at the university which is known to all personnel as the "obstetric routine." This routine consists of a single 14 by 17 inch anteroposterior supine roentgenogram centered about 1 inch above the iliac crest so that it shows the entire uterus and the maternal pelvis. A second 14 by 17 inch roentgenogram is made in the lateral projection centered on the uterus. The third 10 by 12 inch lateral roentgenogram is made of the maternal pelvis centered about one inch above the greater trochanter. The authors believe that these three roentgenograms afford all the information necessary for the great majority of obstetric problems. However, for precise pelvimetry, an additional frontal roentgenogram is made centered directly over the pelvis.

The authors point out that roentgen pelvimetry can be accomplished by any of several methods. All of the methods basically correct for the distortion inherent in roentgenograms.

A rather long list of indications for roentgen examinations during pregnancy is presented This list includes estimation of fetal age, placental localization, evaluation of fetopelvic size relations, evaluation of fetal positions, determination of fetal death,

and confirmation of pregnancy. Mention is made of maternal roentgen chest survey and its importance, and the authors believe that this should be carried out early in the course of the pregnancy. Routine chest roentgenograms in newborn infants have a considerable value and this is also a function of the radiology unit at the University of Michigan.—*R. E. Kinzer, M.D.*

Rozin, Samuel. The diagnosis of tubointestinal and tubovesical fistulas by hysterosalpingography. *Am. J. Obst. & Gynec.*, Dec., 1954, *68*, 1525–1534.

A fistula between the fallopian tube and the intestines or urinary bladder usually develops following pyosalpinx with adhesions to one of the adjacent hollow viscera. Tubal fistulas may also develop after inadequate surgery, particularly where drainage is performed. Adnexal tuberculosis is the most important etiological factor in the development of either spontaneous or postoperative fistulas.

The diagnosis is difficult because there are rarely any clinical signs. Hysterosalpingography provides a means of diagnosing internal tubal fistulas, yet only a few reports of diagnosis by this method are to be found in the literature. Five cases are reported, 4 between the tube and the colon and 1 to the urinary bladder.

The characteristic roentgen findings in cases of tubointestinal and tubovesical fistulas are as follows: (a) The lumen of the involved tubes is usually enlarged, without evidence of peristalsis, and distorted in abnormal position. (b) The lumen of the tube abruptly enlarges to form an unusually large and uneven space. (c) The control film taken one or more hours later, which should not be omitted, shows a very typical picture. The contrast medium assumes the shape of the intestines and coats the mucosal folds. (d) Immediate disappearance of larger quantities of contrast medium from the pelvic region while hysterosalpingography is performed points to the presence of a tubovesical fistula. In these cases the lipiodol is scattered in the form of drops because of the liquid medium, and the location of the lipiodol changes according to the position which the patient assumes. The contrast medium may suddenly disappear if the patient urinates.—*John F. Weigen, M.D.*

Alpert, Meyer, and Lecher, B. Douglas. Opacification of a calcified leiomyoma during hysterosalpingography. *J. Canad. A. Radiologists*, Sept., 1954, *5*, 38–41.

The authors present a case which had a very unusual type finding during hysterosalpingography—the opacification of a calcified uterine fibroid.

The patient was a thirty-three year old white female who had a normal delivery six years ago and in whom uterine fibroids were discovered at a routine postpartum examination. She had a cauterization of the cervix in 1949 because of leukorrhea. Her present illness consisted of vaginal bleeding for the past four months which has gotten worse leading to prolonged flow with passage of clots. Preliminary roentgenogram of the pelvis demonstrated calcification in a fibromyoma on the right side of the uterus; during hysterosalpingography this area filled with lipiodol. The patient was operated on a few days later and the removed uterus showed a small sinus tract extending to the fibromyoma which filled with lipiodol. The patient had an uneventful recovery.—*Neal F. Yeomans, M.D.*

Genitourinary System

Dick, D. R., Herrmann, R. W., Ferguson, Charles, and Hebert, C. L. The use of a short acting, muscle relaxant drug (succinylcholine chloride) in diagnostic urography: a preliminary report. *J. Urol.*, Dec., 1954, *72*, 1260–1262.

Anectine (succinylcholine chloride) is a short acting muscle relaxant that has been found safe and dependable for the production of apnea during general anesthesia. In those patients who require general anesthesia for retrograde pyelograms, this drug is recommended by the authors. A series of 25 patients in whom thiopental and nitrous oxide anesthesia was used for retrograde pyelography showed that apnea can be produced by intravenous injection of anectine in dosages ranging from 10 to 30 mg. Muscular relaxation and apnea appears in twenty to forty seconds and lasts for three to four minutes. The roentgenograms can be exposed during this interval and, when necessary, respiration is carried out by the oxygen and breathing bag. Repeated injections can be made as required for subsequent exposures. The drug is rapidly hydrolyzed so that cumulative effects of overdosage are not frequent.

Of the patients studied, none had any untoward reactions. It must be emphasized, however, that equipment for positive pressure oxygenation and emergency intubation should be immediately available.—*George W. Chamberlin, M.D.*

Idbohrn, Hans. Renal angiography in cases of delayed excretion in intravenous urography. *Acta radiol.*, Nov., 1954, *42*, 333–352.

An analysis of the literature on the diagnosis of renal function by renal angiography is presented. The results of renal angiography in 22 cases with unilateral impaired kidney function are given (19 verified cases and 3 cases verified with reservations).

Preliminary studies indicate the width of the renal artery may be a good guide in the evaluation of the amount of functioning kidney parenchyma. The mean diameter of the renal arteries to the normal kidneys was found to be 7.0 (varied from 5.5–10.0 mm.), while the mean diameter of the renal arteries

to the obstructed kidneys was 4.5 mm. (varied from 3.0 mm. to 7.0 mm.).

Wide variations in arterial diameter exist which may lead to overestimation or underestimation of function. The author feels that a larger series of cases is necessary before a more definite opinion about the significance of the differences in the caliber of the renal arteries may be determined.—*George A. Miller, M.D.*

Truscott, D. E. The radiological control of kidney injuries. *J. Fac. Radiologists*, July, 1954, *6*, 38–47.

It is in the assessment and management of any individual case of kidney injury, but especially in the control of conservative treatment, that roentgenological aid is invaluable. The examination consists of plain films of the abdomen and intravenous urography. When the period of shock has passed and the blood pressure has returned to normal levels, there is no contraindication to intravenous urography provided that the investigation is controlled from beginning to end by the radiologist. It is considered that there is no place for retrograde pyelography in these cases. The dangers of causing further hemorrhage or of introducing infection are too great to permit the use of this method.

Technically, the examination is carried out by first making a roentgenogram with the film placed transversely across the upper abdomen and then making a second roentgenogram with the film placed parallel to the long axis of the body with its lowest margin an inch below the symphysis pubis and with the tube centered to the film. Following intravenous injection of a contrast medium, films of the kidney area are exposed at 5, 15 and 30 minutes, and at 30 minutes a roentgenogram of the lower urinary tract is also made.

On the plain roentgenogram one may see a slight "protective" scoliosis concave to the affected side; obliteration of the psoas shadow; loss of the kidney outline; fullness of the affected flank; injury to the bony skeleton, usually the 12th rib or the upper lumbar transverse processes; meteorism of the bowel, often very marked and frequently localized over the injured kidney. On intravenous urography one may note failure of visualization of a calyx; irregularity of one or more calyces; calyceal rupture (intracapsular) as evidenced by a pool of contrast medium contained within the kidney outline; extracapsular rupture of a kidney which is seen as a pool of contrast medium not contained within the renal outline; failure to excrete or diminished excretion of contrast medium by the affected kidney; and displacement of the kidney or deviation of the ureter by the retroperitoneal hematoma. One of the most important functions of the urographic examination is the demonstration of the presence and condition of the unaffected kidney, this knowledge being essential and making the investigation imperative when nephrectomy is a possibility. Moreover, intravenous urography may reveal the presence of a previously unsuspected gross renal pathology. A normal pyelogram on intravenous urography does not exclude in theory a parenchymal or subcapsular tear, but the author's experience has been that in the presence of renal injury, the urogram, has revealed a definite abnormality on every occasion. When hematuria is so severe as to make the surgeon consider nephrectomy to prevent further blood loss, a pyelogram that shows a functioning and comparatively mildly injured kidney may lead him to persevere with conservative treatment. The finding of a functionless kidney may influence the surgeon towards nephrectomy, but a kidney which is functionless following injury can recover completely.

The following is one of several case reports presented in this article: A fourteen year old boy was admitted with a story of hematuria following a fall over a cliff some hours earlier. Immediate urography showed complete absence of function on the injured side. Conservative treatment was followed by reexamination two weeks later; this showed complete return to normal, with no residual deformity.—*Samuel G. Henderson, M.D.*

Keshishian, John M., and Spencer, William A. Visualization of the inferior vena cava as an adjunct to diagnosis of retroperitoneal tumors, a case report. *Ann. Surg.*, Dec., 1954, *140*, 892–896.

The authors present a report of a case of retroperitoneal tumor, proving to be a renal cell carcinoma. Localization of this tumor was aided by visualizing a displaced inferior vena cava.

A fifty-six year old white male was hospitalized with a questionable mass in the right abdomen. Intravenous urography revealed a density in the mid right abdomen in the angle between the 12th rib and the spine. The upper right ureter was displaced laterally. Right retrograde pyelography confirmed these findings. Gastrointestinal examination showed a "small pressure defect on the lesser curvature side of the duodenal bulb." Inferior vena cavagram with 50 cc. of 70 per cent urokon showed the inferior vena cava to be displaced to the right and anteriorly at L1 and L2 without obstruction. Presacral pneumography, with laminagraphy, showed the mass and the kidney to occupy approximately the same plane.

Surgery through a nephrectomy approach revealed a large, 9 cm. tumor below and posterior to the kidney. Further exploration revealed "daughter" tumors in and about the kidney. Nephrectomy en bloc was carried out. Surgery was followed by roentgen therapy, with a total dose of 3,000 r.

The authors feel that lateral displacement of the inferior vena cava, without obstruction of the vessel, strongly supports a diagnosis of retroperitoneal le-

sion; and that visualization of this organ should be more commonly employed.—*L. E. Sargent, M.D.*

Comarr, A. Estin. Renal changes in paraplegia as screened by routine excretory urography. *J. Urol.*, Oct., 1954, *72*, 596–605.

The author reviewed 315 pyelograms of patients with spinal cord trauma or disease, 289 of patients with various cord lesions, and 26 of patients with tumors of the spinal cord. Among the evaluated 630 pyelograms, irrespective of the level of the spinal cord lesion, or of the completeness or type of cord lesion and time since injury, 73 per cent were essentially normal; 12 per cent showed mild dilatation of the calyces or pelvis; 8 per cent were graded as showing a moderate degree of pyelectasis or calyectasis; and 6 per cent showed severe changes incident to gross hydronephrosis. The right kidney showed somewhat more frequent pathological changes than the left. The incidence of renal disease was higher in those patients whose spinal cord lesion was below the level of D12, but there was no apparent relationship between the incidence of renal involvement and the extent of the cord lesion.

The pathological changes in the kidneys tended to increase with the time elapsed since injury. The earliest lesions were seen in two months; moderately advanced lesions in eight months; and the severe lesions ten months after injury.

Several examples are given to show that a properly functioning cord bladder is, of itself, not the only factor in the production of renal damage in these patients. It is impossible to prognosticate the future of kidneys in neurogenic bladders by judging the bladder function alone. Most of the patients with well functioning suprapubic cystotomies are free from frequent pyelonephritic episodes, even though they may have vesico-ureteral reflux.—*George W. Chamberlin, M.D.*

Wilhelm, Seymour F. Gas insufflation through the lumbar and presacral routes. *Surg., Gynec. & Obst.*, Sept., 1954, *99*, 319–323.

The author describes the technique of the lumbar and presacral methods of air insufflation and presents a comparative study of both.

The chief hazards of perirenal insufflation regardless of which route is used, are (1) air embolism, (2) infection, (3) perforation of and injury to adjacent organs. The two-bottle pneumothorax apparatus as used by the author in 150 cases resulted in no complications, while air embolism may be a serious and fatal complication when rapid injection is made by a hand syringe, as reported in the literature.

The proximity of the rectum and anus makes bacterial contamination more likely when the presacral approach is used. The author reports the absence of infection in 150 cases examined through the lumbar route and in 67 by the presacral route.

Perforation of the kidney or penetration into the peritoneal cavity, when the lumbar route is used, are complications to be guarded against. Kidney perforation is evidenced by withdrawal of blood into the syringe and occurred several times in the author's series. When the presacral route is used perforation of the rectum is the chief danger. The insertion of the operator's finger into the rectum is a recommended procedure to guide the needle and prevent perforation.

While the presacral route permits visualization of both kidneys and adrenal glands at one time, as compared with the lumbar technique which permits visualization of only one side at a time, the possibility of infection is greater. Furthermore, the need of excessive amounts of air (800 to 1,250 cc.) creates massive retroperitoneal emphysema.

The author does not feel that the choice of gas (oxygen, carbon dioxide or helium) makes any difference in the safety of the procedure. Embolism occurs as a result of sudden mechanical blockage of large gas bubbles, especially in the right ventricle irrespective of the kind of gas used.

Four reproductions of roentgenograms accompany the article.—*William H. Shehadi, M.D.*

Weens, H. Stephen, and Florence, Thomas J. The diagnosis of hydronephrosis by percutaneous renal puncture. *J. Urol.*, Oct., 1954, *72*, 589–595.

In certain patients where conventional roentgenographic procedures have failed to demonstrate the nature of the lesion involving the kidney, percutaneous puncture using an 18 gauge needle, may establish the diagnosis.

The patient is placed prone on the roentgenographic table and the skin cleansed in the usual fashion. If the kidney is not palpable, it may be localized by the use of lead markers on the skin over the lumbar area. The roentgenogram taken with the markers in position should determine the optimum site for the needle puncture. If a palpable mass is present, this procedure is usually unnecessary. The puncture is made just lateral to the longitudinal muscles of the back and usually just below the last rib on the suspected side. When urine is obtained, a small amount is aspirated for examination and the contrast medium injected. The roentgenogram is then taken with the patient in the prone position.

The authors report, in detail, 4 patients in whom successful demonstration of hydronephrosis was obtained by this procedure.—*George W. Chamberlin, M.D.*

Garrett, Robert A., Norris, Max S., and Vellios, Frank. Renal papillary necrosis: a clinicopathologic study. *J. Urol.*, Oct., 1954, *72*, 609–617.

The authors add 6 cases to the 160 already reported in the literature.

The disease is characterized clinically by dysuria, hematuria, chills, fever, nausea and vomiting. It occurs somewhat more frequently in diabetic individuals and particularly in diabetic females. In the nondiabetic individuals it is observed somewhat more frequently in the male than in the female. Its course may be acute and fulminating or chronic and progressive. Four of the 6 patients in this series showed characteristic renal colic; 3 showed prostration and stupor; and 2 were in coma. All but 1 were diabetic females without urinary tract obstruction. Four patients were aged forty to sixty years and 1 was twenty-one years of age. Four of the patients manifested typical fulminating and rapidly fatal course of the disease; 2 of them are living and well, approximately two years later. In 1 patient the diagnosis was established ante mortem by histological study of the tip of the renal papilla which was excreted in the urine.

The roentgen changes during the acute stage of the disease, as seen in the retrograde pyelogram, may show ragged, irregular calyces, somewhat suggestive of renal tuberculosis. Separation of the papilla will leave a ring shadow surrounding a nonopaque filling defect in a minor calyx. This is a relatively uncommon finding, but when present is quite diagnostic. After necrosis of the renal papilla, the pyelograms show evidence of blunting of the calyces without dilatation of the renal pelvis and in the late stages, pyelonephritic contracture with both clubbed and ragged calyces may be present.

The management of these cases must include prompt control of the infection, establishment of adequate drainage and in those instances which are definitely unilateral, nephrectomy may be indicated as a life saving procedure. The control of the diabetic state is, of course, necessary.—*George W. Chamberlin, M.D.*

NERVOUS SYSTEM

CHAMBERS, WILLIAM R. Diastematomyelia; report of a case diagnosed preoperatively. *J. Pediat.*, Dec., 1954, *45*, 668–671.

Diastematomyelia consists of a congenital cleft of the spinal cord through which usually extends a spicule of bone or a fibrous band on which the cord is impaled. The cord is thus transfixed in a low fetal position, and the traction on and splitting of the cord by the impaling object produces neurological deficit. Although asymptomatic initially, the condition produces disabling symptoms as the individual grows.

Since the majority of these cases are amenable to surgery, recognition of the roentgenological features which may lead to the correct diagnosis is extremely important. The three most important signs are spina bifida, increase in interpedicular measurements, and a midline bony spicule. Other anomalies of the vertebra may be encountered and there is often an associated external abnormality of the back, consisting of a small dimple, a hairy patch, or a bony deformity.

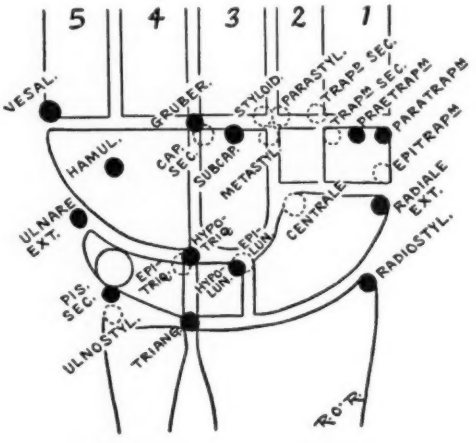
In 1950, Matson and collaborators reported 9 cases in which the diagnosis had been made preoperatively, and Neuhauser and associates reported an additional 10 cases. To these is added a report of another case diagnosed before surgery by attention to the significant roentgenographic signs.—*Lois Cowan Collins, M.D.*

SKELETAL SYSTEM

O'RAHILLY, RONAN. A survey of carpal and tarsal anomalies. *J. Bone & Joint Surg.*, July, 1953, *35-A*, 626–642.

In this paper the similarities between carpal and tarsal anomalies are stressed and the chief anomalies are described and reviewed. These are: (1) extensive anomalies associated with antebrachial (crural) and/or digital abnormalities, such as absence of the radius and thumb; (2) "fusions"; (3) accessory ossicles, including sesamoids; (4) bipartite bones.

"Fusions" (or non-separations) have been found in almost every possible combination between carpal

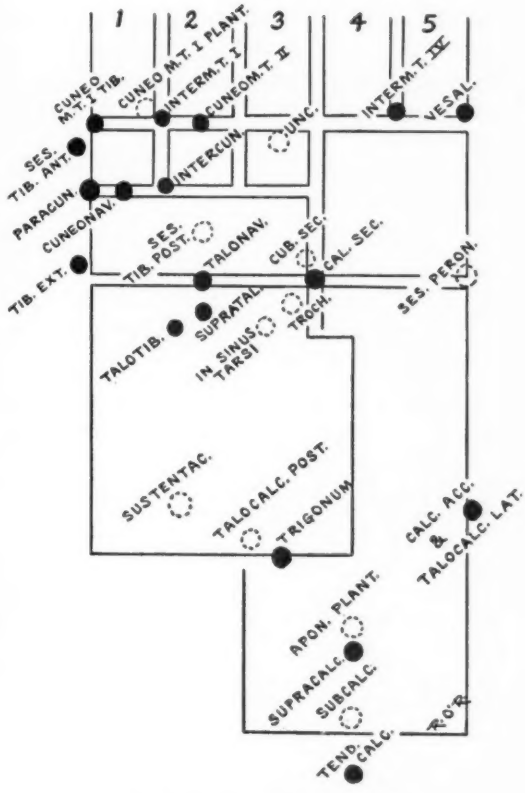


CARPAL ACCESSORIA

FIG. 1. Carpal accessoria. Scheme of right carpus, palmar aspect, showing sites of accessory carpal ossicles. The more dorsally situated ossicles are shown in broken outline. (Reproduced by permission of *The Journal of Bone and Joint Surgery*.)

or tarsal bones. They probably arise as an absence of joint cavitation in utero, and chondrification of the developing "interzone." In the hand, lunatotriquetral is the most frequent type and has a higher incidence in negroid people; in the foot, "peroneal spastic flatfoot" has been attributed to talocalcanean or calcaneonavicular fusions.

The accessory carpal and tarsal elements at present known (about 24 in the carpus and 30 in the tarsus) are listed and their position is described (see



TARSAL ACCESSORIA

Fig. 2. Tarsal accessoria. Scheme of right tarsus, dorsal aspect, showing sites of accessory tarsal ossicles. The more plantar-situated ossicles are shown in broken outline. (Reproduced by permission of *The Jorunal of Bone and Joint Surgery*.)

Fig. 1 and 2). Some of these have been found in the fetus (the centrale is almost constant) but in some instances postnatal traumatic and pathological factors are operative (a given type of accessory bone may have different origins in different individuals). The embryological significance of the accessoria remains very obscure and most of the so-called "explanations" based on phylogenetic theories are quite unjustified in the present state of knowledge. A number of accessory bones exhibit "bilocation," that is, they may occur either *at* or *as* a process on one of the major elements; thus the styloideum may occur either in association with a well developed third metacarpal styloid process or in place of that process.

Most divisions of bones are produced through trauma but a few seem to be congenital. Bipartite scaphoid probably arises from two mesenchymal or cartilaginous centers. The division is at the waist of the bone but it is questionable whether roentgenological criteria can be adequate in evaluating the congenital nature of a given case. The best-attested tarsal bone subject to congenital division is the medial cuneiform, which occurs as dorsal and plantar parts. Endocrine factors (as in hypothyroid epiphyseal dysgenesis) may be operative in some cases of bipartition.—*Author's abstract.*

Stewart, Marcus J. Fractures of the carpal navicular (scaphoid); a report of 436 cases. *J. Bone & Joint Surg.*, Oct., 1954, *36-A*, 998–1006.

In this article the results of a study of 436 cases of fracture of the carpal navicular are reported. The author states that diagnostic errors are more common in fractures of this bone than in fractures of any other bone of the body. He considers that, without exception, such a fracture is produced by a force transmitted through the proximal phalanx of the hand. There are four types of carpal navicular fractures, although any combination of these types may occur: (1) fracture of the tubercle; (2) fracture of the distal third; (3) fracture of the middle third or waist. The majority were of this type in the series (80.45 per cent); (4) fracture of the proximal third.

In his conclusions he states that every severe sprain or injury in the region of the carpal navicular should be considered a fracture until otherwise proved. If a fracture of this bone is accurately reduced and adequately immobilized for a sufficient time, solid bony union may be expected. In delayed treatment, the presence of vacuolation or cystic change is not considered discouraging. When the fracture has been properly immobilized, the healing which takes place in the cystic area will include the fracture line. If the proximal fragment is viable, sclerosis at the site of fracture is no contraindication to prolonged immobilization. As a rule, after two or three months of uninterrupted immobilization, decalcification of the sclerosis will be observed, signs of union will follow, and ultimately solid bony union will take place.

Rarely, according to the author, will normal function be obtained following excision. Bone grafting and drilling will not, except in an occasional case, offer any better prospect of union, nor will they, as a rule, reduce the average period of disability. The early excision of the proximal fragment in the occasional fracture with excessive displacement of the proximal fragment, is recommended, unless accurate reduction can be obtained by manipulation. The type of plaster cast which is recommended by the author secures adequate immobilization of the navicular and allows the patient excellent use of the hand. Immobilization may be prolonged for a year or more if daily exercise and activity of the fingers are systematically practiced.

The article is illustrated with reproductions of serial roentgenograms of some of the cases.—*Ralph S. Bromer, M.D.*

Knickerbocker, T. W., and Reilly, Ralph. Traumatic epidermoid cyst of the terminal phalanx. *Radiology*, Oct., 1954, *63*, 550.

Traumatic epidermoid cyst of the terminal phalanx must be differentiated from chondroma, sarcoma, simple cyst, and giant cell tumor. The history of formation of a fluctuant expansive cystic mass months to years after trauma to the finger is characteristic. Sebaceous epithelium is driven into the bone with subsequent cystic erosion or expansion of the phalanx.

Complete removal of the cyst is curative.

Microscopically similar lesions of the skull, brain, and spinal cord have been found, but those are believed to result from embryonal maldevelopment, rather than trauma.—*C. L. Stevenson, M.D.*

Stiepan, Frederick E. Giant-cell tumor of the head of the humerus; with a case report. *J. Bone & Joint Surg.*, Oct., 1954, *36-A*, 1014–1019.

The author states that it is not generally known that giant cell tumors of the head of the humerus which amount to about 6 per cent of the total of all giant cell tumors carry a surprisingly poor prognosis. In this article a case is reported of a giant cell tumor in the proximal portion of the humerus which was treated by primary resection and insertion of an acrylic prosthesis.

Roentgenograms revealed a large cystic radiolucent type of tumor involving the head of the humerus. The bony wall of the tumor was fractured. The cortex was greatly thinned but there was very little expansion. On the basis of the classification of Jaffe and his associates the tumor was classified grade 2 (recurrence probable, possibly becoming malignant eventually).

Unlike the most frequently occurring type of giant cell tumor, which involves the region of the knee, tumors of the proximal end of the humerus are usually very large and are often found to involve the entire diameter of the shaft when they are first discovered. This, the author feels, is due to the fact that they are not subjected to weight-bearing forces and are concealed deep beneath the deltoid muscle, so that they enlarge to a considerable size before their presence becomes evident.

When end results of treatment are considered, giant cell tumors of the proximal end of the humerus show a high mortality rate because of their sarcomatous potentiality. Resection is the treatment of choice and the problem of replacement of the head of the humerus has been simplified by the development and wider use of prostheses.—*Ralph S. Bromer, M.D.*

Ford, Lee T., and Key, J. Albert. The differential diagnosis of shoulder, upper back and neck pain and the conservative treatment of cervical disc lesions. *South. M. J.*, Oct., 1954, *47*, 961–968.

The authors believe that in many instances complaints diagnosed as cervical myositis, myofascitis, myalgia, neuritis, "cricks," sprains, scalenus anticus syndrome, and arthritis actually represent the result of intervertebral disc pathology in the lower cervical spine.

The cervical disc contains a nucleus pulposus which is surrounded by an annulus fibrosus and is subject to the same traumatic and degenerative changes as are the lumbar discs. Disc ruptures in the cervical spine are most often small and situated laterally, producing neck and radicular pain.

Roentgenograms taken a short time after onset of symptoms often show degenerative changes which must have been present for some time before symptoms developed. Occasionally, the roentgenograms are negative but, in most cases, some change is present. There may be only diminution or reversal of the normal cervical lordotic curve. The interspace may be narrowed; sclerosis and spurring may have appeared. Subluxation may be present. Roentgenograms are important in differential diagnosis, and should be a routine part of the investigation of neck and radicular pain. Myelography and lumbar puncture are performed only if operative intervention is contemplated.

Treatment by conservative measures will provide gradual relief in over 95 per cent of cases. The authors recommend rest, as provided by a Thomas collar, and the use of traction with or without manipulation.—*George Cooper, Jr., M.D.*

James, J. I. P. Scoliosis in children. *Brit. J. Radiol.*, Sept., 1954, *27*, 511–523.

Scoliosis is defined as a lateral curvature of the spine and the author points out that there are two types of scoliosis, namely, scoliosis with structural deformity and scoliosis without structural deformity. Differentiation of these types of scoliosis is apparently easy and is demonstrated by photographs of children bending forward. When a patient with a postural or compensatory scoliosis bends forward there is no persisting rotation. When there is a structural curvature there will be a persistent rotation even when in the flexion position.

The common causes of structural scoliosis include idiopathy, poliomyelitis, congenital abnormalities of bone, and neurofibromatosis. Each type of structural scoliosis is considered separately. In the idiopathic type of scoliosis, the site of the primary curve and the age of onset are the important factors in terms of prognosis. The common paralytic scoliosis is usually secondary to unilateral intercostal paralysis and lateral abdominal paralysis. The high thoracic paralytic scoliosis is difficult to cope with and the curve frequently becomes severe. Congenital scoliosis is said to be common but often the multiple vertebral

anomalies complement each other and the spine does not become markedly deformed. The author notes that the proper roentgenographic examination should consists of an anteroposterior exposure made with the patient erect on a 14×17 inch size film. Measurement of the primary curve is important and gives immediate information as to the progress of the scoliosis.

Conservative and surgical type of treatment are discussed.—*R. E. Kinzer, M.D.*

Compere, Edward L., Johnson, William E., and Coventry, Mark B. Vertebra plana (Calvé's disease) due to eosinophilic granuloma. *J. Bone & Joint Surg.*, Oct., 1954, *36-A*, 969–980.

In this article 4 patients who had eosinophilic involvement of a vertebral body with typical symptoms of vertebral plana as described originally by Calvé, are reported. In all 4 patients only one vertebral body was affected but in 2 patients there were also lesions in one or more ribs. Among the findings reported by Calvé and which were also noted in the cases reported here are the following:

(1) Only one vertebra was involved; (2) adjacent discs were intact above and below the diseased vertebra; (3) disc spaces were actually about a third wider than the next spaces above and below except in one case in which the disc space was narrowed; (4) the vertebrae which had been completely flattened appeared as dense cortical discs and resembled the edge of a silver dollar. The authors believe that Calvé's disease is a syndrome found in young children and is characterized by pain in the back, with the usual signs of muscle spasm, tenderness, and rigidity. The roentgenographic findings in the typical case reveal the involvement of one vertebral body by a process that produces a dense appearing vertebra which is evenly flattened front and back and simulates the edge of a silver dollar.

Biopsy, either by the open method or punch and curette, was done in the 4 cases and showed microscopic changes of eosinophilic granuloma. In one case the biopsy was performed on one of the rib lesions.

Several authors have considered Calvé's disease to be a form of avascular necrosis similar to that seen in the head of the femur (coxa plana). It is the authors' feeling that, while other conditions may cause collapse of a single vertebra in young children, the clinical and roentgenological picture is not similar to that in the cases they present. One of the authors (Compere) in his closing discussion states, "I would like to make it clear that we are not by any means suggesting that it (eosinophilic granuloma) is the only cause of vertebra plana but it is the only one we know about."

The treatment of the cases consisted in splinting and rest. Gradually the lesions became less painful. The vertebral body may reossify with little loss of height and with strong bony trabeculation. Recovery according to the regimen recommended, requires one to three years. Roentgen therapy was used in each of the 4 cases reported and healing was rapid with relief of symptoms in a matter of months.—*Ralph S. Bromer, M.D.*

Cleveland, Mather, and Fielding, J. William. A continuing end-result study of intracapsular fracture of the neck of the femur. *J. Bone & Joint Surg.*, Oct., 1954, *36-A*, 1020–1030.

In their introductory paragraph the authors state that the intracapsular fracture of the neck of the femur remains a serious problem for which there is no ready answer. The enthusiastic resort to prosthetic devices which originated in France and is spreading to all parts of the world has led or, rather, misled, some surgeons, who should know better, to advocate the immediate use of a metal or plastic substitute for the femoral head in fresh fractures of the neck of the femur. There is no really satisfactory substitute for an intact femoral head and neck.

They present a study of 100 additional intracapsular fractures of the neck of the femur with a 94 per cent follow-up. Previously a series of 125 patients had been reported by them. Only 82 patients of the present series could be fully studied because 6 were lost to follow-up and 12 died before the end results could be determined. Eighty-three per cent of these patients were women and the average age of the group was seventy-two years at the time of fracture.

All but one of the nineteen fractures without displacement united without complications within four months of the operation. The incidence of union in the group of 63 patients with fractures with displacement was almost 78 per cent. Union of these fractures with displacement in the current series occurred in an average of 7.5 months after reduction and fixation. Circulatory disturbance in the femoral head of united fractures with displacement occurred in almost 25 per cent, but only 8 of the 13 patients who had this complication showed subjective or objective evidence of disability.

Considering the entire group of 82 patients available for study, the authors had completely satisfactory results, that is union of the fracture with no evidence of circulatory impairment of the femoral head, in 67 per cent. If the 5 patients with asymptomatic circulatory disturbance were included, 73.1 per cent might be claimed to have had satisfactory results.

Considering the fractures with displacement alone, completely satisfactory results occurred in slightly under 57.2 per cent. If the 4 patients in this group with asymptomatic circulatory distrubance of the femoral head were considered to have had satisfactory results, a claim could be made for 65 per cent of the fractures with displacement.

In conclusion, the authors state that they have

learned how to improve some of their unsatisfactory results by means of a prosthetic hip replacement when it is properly indicated, with due regard to the limitation of such a replacement. They are not ready to render a final opinion on this matter at this time. They have, however, seen no prosthetic hip replacement which can compare favorably with a united fracture with a living head.—*Ralph S. Bromer, M.D.*

Carr, Chalmers R., Berley, Ferdinand V., and Davis, W. Clayton. Pigmented villonodular synovitis of the hip joint; case report. *J. Bone & Joint Surg.*, Oct., 1954, *36-A*, 1007–1013.

In this article a case of pigmented villonodular synovitis of the hip joint is reported which had retroperitoneal extension simulating an abdominal tumor. The patient was a male, twenty-seven years old, who had noted a gradually enlarging mass in the left femoral triangle two weeks before his admission to the hospital. Two days after the onset there was a concurrent mass in the left lower abdominal quadrant. Roentgenographic studies showed an effective right eight-rib thoracoplasty which was the result of a previous operation for active pulmonary tuberculosis. The roentgenograms of the abdomen revealed a mild bulge of the psoas shadow and a soft tissue mass overlying the wing of the left ilium. The examination of the spine showed a normal appearance of the thoracic and lumbar portions but that of the hip showed areas of rarefaction in the left acetabular rim and in the head of the femur. Intravenous and retrograde pyleograms demonstrated the left ureter to be displaced to the midline from the level of the fourth lumbar vertebra to the third sacral segment. A barium enema examination showed the sigmoid colon to be displaced medially. At operation a large cystic mass, covered with attenuated psoas muscle was found. The mass was U-shaped. The anterior component communicated at the femoral ring with a posterior cyst which extended inside the psoas muscle. The cyst lining was xanthomatous and contained, in addition to viscous fluid, masses of greenish yellow nodular tissue apparently undergoing degeneration.

A search of the literature by the authors failed to reveal a retroperitoneal extension of a lesion such as is reported in this article. The possibility of a pigmented villous synovial lesion must be considered, they feel, in the differential diagnosis of tumors of the lower abdomen. Previous authors have atempted to classify pigmented villonodualar synovitis as a synovial lesion constituting an intermediate group between lesions which are clearly inflammatory and those which are definitely neoplastic. No consistent etiological factor has been found. Some writers state that trauma is usually linked with the onset.—*Ralph S. Bromer, M.D.*

Fawcitt, John. The radiological pattern of pseudocoxalgia. *Brit. J. Radiol.*, Sept., 1954, *27*, 504–510.

The author has studied the case histories and roentgenograms of 94 children, with 106 hips affected by Perthes' disease. He feels that the usual roentgenographic assessment of this disease leaves much to be desired and that it is advantageous to take roentgenograms not only in anteroposterior and oblique views but also in views with the hip in full internal and in full external rotation. These should be made if at all possible before treatment is instituted, when immobilization is discontinued and particularly before weight bearing is commenced.

It is known that degenerative changes frequently occur later in life in hip joints affected by Perthes' disease. In the present series no long term follow-up was attempted but it was noted that unfavorable roentgenological results were more frequent in patients who developed the disease between 9 and 13 years of age, less frequent in the 6 to 8 year old group and considerably less frequent in the birth to 5 year old group. It was also observed in this series that if frank pseudocoxalgia occurred in each hip, with an interval between its commencement, it was always the second hip which was the more severely affected and which gave the poorer end result.

There were 6 abortive cases in which the return to normal density was more rapid than usual and the degree of reformation was more complete. Sometimes in bilateral cases, when one hip was frankly involved, the other femoral head trembled on the brink, condensed slightly and returned practically to normal in a few months.—*Arthur E. Childe, M.D.*

Urist, Marshall R., Mazet, Robert, Jr., and McLean, Franklin C. The pathogenesis and treatment of delayed union and nonunion; a survey of eighty-five ununited fractures of the shaft of the tibia and one hundred control cases with similar injuries. *J. Bone & Joint Surg.*, Oct., 1954, *36-A*, 931–968.

This article gives a very detailed discussion and presentation of results of the study of 85 cases of ununited fracture of the shaft of the tibia and 100 cases with similar injuries. Fractures through the dense compact bone of the shaft of the tibia are predisposed to show slow healing and non-union. While the overall incidence of delayed union or non-union has been estimated at less than 3 per cent for the skeleton as a whole, it has been reported in the tibia to be as high as 7 per cent for selected non-comminuted fractures, 9 per cent for unselected consecutive cases.

The following is the definition of terms used in the article:

Delayed union is a term with arbitrary meaning

applied to ununited fractures in which (1) the roentgen examination at any time from four to eighteen months of healing shows inadequate callus and (2) the judgment of the individual surgeon leds him to advise a surgical operation to stimulate healing of the fracture.

Non-union is used as a more specific term and is reserved for ununited fractures in which the roentgenographic examination after eighteen months of healing shows (1) a bone defect, (2) false motion, (3) sclerosis of the bone ends, (4) rounding, mushrooming, or molding of the fracture surfaces, and (5) sealing of the medullary canal with compact bone to form functioning false joint surfaces and an apparent arrest of the process of osteogenesis in the fracture gap.

In a previous article by two of the authors the observations upon experimental healing of fractures were presented and they form the background of the present study. In both experimental and clinical fractures, bone formation always begins in the fracture site by the proliferation of the periosteum or endosteum at some distance from the line of the fracture and grows into it by extension from these tissues. The periosteal reaction, wherever it occurs, is intramembranous ossification; the endosteal reaction is appositional bone fomation. In both instances, the new born formation can be assumed to originate from cells which are linear descendants of osteoblasts.

Another form of ossification also appears in connection with healing fractures and is particularly important when a gap must be bridged between the bone ends. The process begins with the formation of fibrocartilaginous tissue between the fracture fragments. Fibrocartilaginous tissue or fibrous tissue is developed in the fracture site, even when the fracture is microscopic and the bone ends have been compressed by mechanical instruments. Its appearance is similar to that seen in fetal osteogenesis and is the preliminary step in the bridging of the fracture. The observations which are presented in this article suggest that non-union results from fibrinoid degeneration in the interior of the callus and failure to establish an effective induction system for osteogenesis to proceed across the fracture gap.

The mechanism of non-union of fractures of the tibia, as described in the summary of the article, is fibrinoid degeneration of connective tissue in the interior of the callus and this is common to all clinical circumstances of the condition. Fibrinoid forms when the bone injury has been extensive, has been complicated by infection, or has been difficult to immobilize. Fibrinoid indicates a defective callus and is not a simple barrier to osteogenesis. It fails to draw osteogenesis from the periosteum and endosteum across the fracture gap. According to interpretations of the newer theory of osteogenesis, it lacks the ability of cartilage and fibrocartilage to promote new-bone formation by induction.

The effect of open operation on fresh fractures is to increase the volume of damaged bone which has to be absorbed and replaced before the fracture can unite and permit full weight-bearing on the leg. Comminuted fractures of the shaft of the human adult tibia should be considered non-operable fractures during the first six months of healing, because the trauma added by surgery exceeds the normal capacity for bone regeneration in this area of the skeleton.

Bone grafting, without excision of the fibrocartilaginous callus, may be applied successfully in ununited fractures of the tibia before eighteen months of healing. Excision of the pseudarthrosis, osteotomy of the fibula, and telescoping of the fracture ends are advisable in ununited fractures after eighteen months. All of the standard surgical procedures of onlay, inlay, or intramedullary bone grafts are capable of producing union with the aid of one additional year of immobilization of the fracture, but the success of the operation is determined by the proliferation of the bone ends, not the bone graft. If the bone ends are in close contact the function of the graft appears to be that of an inductor.

Recurrence of sepsis is the chief cause of failure of all types of bone graft operations. Roentgenograms which show a diffuse increase in density of bone tissue 3 or 4 cm. above and below the fracture line indicate latent sepsis. In such cases six months or even two years, without drainage is not a safe period of waiting to permit a bone graft operation. Only synostosis operations which avoid the fracture site are free of risks of further damage to the bone ends by infection. Radical leg shortening procedures are an alternative to amputation and may be applicable in old ununited fractures with large soft tissue defects after repeated failure of bone grafting operations.

The article is profusely illustrated with roentgenograms, photomicrographs, line drawings and graphs, the last showing end-results of the clinical cases.—*Ralph S. Bromer, M.D.*

Wellens, P., and Jansen, W. Considérations relatives aux lésions osseuses de la maladie de Hodgkin. (Considerations on the osseous lesions of Hodgkin's disease.) *J. belge de radiol.*, 1954, *37*, 441–453.

The authors report 37 cases of the skeletal involvement in 231 cases of Hodgkin's disease studied by them. This represents a 16 per cent osseous pathology, which corresponds to the statistical findings of other investigators. The lesions were all discovered by roentgen examination, usually not in the terminal stages of the disease. Some cases had multiple bone involvement. The greatest incidence was observed in patients between twenty and fifty years of age, equally distributed in both sexes.

The following conclusions were reached: The hematogenous osseous lesions appear to be more frequent than the contiguous invasion of bones. Fifty

per cent of the bone lesions are found in the vertebral column, especially in the dorsolumbar spine. In order of decreasing frequency lesions are also found in ribs, pelvis, sternum and bones of the extremities. The roentgenographic appearance of the involved bones has no pathognomonic significance; however, in the authors' series about 71.5 per cent showed an osteolytic erosion, 18 per cent showed osteoplastic changes and 10.5 per cent a mixed appearance. According to the authors, the prognosis of Hodgkin's disease is not altered by the osseous involvement.—*J. N. Sarian, M.D.*

Komins, Cecil. Familial metaphyseal dysplasia (Pyle's disease). *Brit. J. Radiol.*, Dec., 1954, *27*, 670–675.

Familial metaphyseal dysplasia (Pyle's disease) is an extremely rare congenital bone dystrophy. The chief characteristic is a smooth expansion at the ends of the long bones.

Smith and Jones in 1910, and Ingalls in 1933 were credited with descriptions of this condition. In 1931 Pyle gave the first clinical and roentgenological report of a tall healthy male child with a large head, "knock-knees." and roentgenographic evidence of symmetrical expansion and thin cortices at the ends of the long bones. In 1937 Bakwin and Kidra reported further on this case and described similar changes in the child's youngest sister. They suggested the term "familial metaphyseal dysplasia." In 1953 Hermel, Gershon-Cohen and Jones reported 2 more cases in a brother and sister, aged thirty-three and thirty-four years respectively. A fifth case was mentioned by Neuhauser in 1953.

The author reports the sixth and seventh cases in a brother of eighteen years, and a sister of thirty-eight years of age. In the male, prognathism and dental caries were marked. In both cases the skeletons were large. Besides enlargement of the skulls, the vaults were thick and there was marked hyperostosis involving the facial bones and bases. The normal dorsal and lumbar curves were absent. The supra-acetabular regions of the iliac bones were widened. The inner halves of the clavicles were expanded. The metaphyseal ends of all of the long bones were expanded and showed thin cortices. The proximal and middle phalanges of some fingers and the proximal phalanges of the great toes showed an even tubular appearance.

In the differential diagnosis, some cases of cleidocranial dysostosis, advanced osteopetrosis, acquired metabolic diseases of infancy and childhood and Gaucher's disease should be considered. Similar skull changes have been noted in fibrous dysplasia. Some cases of leontiasis ossea may prove to be the same disease.—*J. N. Ané, M.D.*

Baker, S. L. General softening of bone due to metabolic causes. I. The histopathology of porotic and malacic conditions of bone. *Brit. J. Radiol.*, Nov., 1954, *27*, 604.

The author states that generalized weakening of bone is caused either by a marked porosis or by imperfect calcification. He defines porosis as a condition in which the bone tissue is reduced in amount but contains the normal amount of calcium. Osteomalacia is defined as a condition in which there is imperfect calcification of bone. The two conditions may coexist.

The parathyroid hormone stimulates osteoclastic activity. Hyperparathyroidism may be either primary, due to a functioning adenoma, or secondary due to some factor producing a hyperfunction of parathyroid tissue. In either case there is a resultant porosis of bone. The absorbed bone is replaced by connective tissue and results in so-called "osteitis fibrosa."

The author differentiates "renal rickets" from nutritional rickets. Renal rickets usually reveals an osteitis fibrosa, which often predominates late in the disease, and which he believes results from a secondary hyperparathyroidism caused by a decreased level of blood calcium.—*D. V. Campbell, M.D.*

Dent, C. E., and Hodson, C. J. Generalised softening of bone due to metabolic causes. II. Radiological changes associated with certain metabolic bone diseases. *Brit. J. Radiol.*, Nov., 1954, *27*, 605–618.

The authors discuss the roentgenographic changes in generalized osteoporosis, rickets and osteomalacia, and primary and secondary hyperparathyroidism. They present numerous cases and attempt to answer the following questions:

(1) How valuable is roentgenographic evidence in the detection of these diseases?
(2) How far can this evidence be used for an exact etiological diagnosis?
(3) How useful is it when linked with the clinical data for etiology, response to treatment and prognosis?
(4) How far can roentgenographic changes be correlated with the disease?

The authors believe that the roentgenographic changes in osteoporosis are nonspecific, since any disease with diffuse bone rarefaction may produce identical alterations. They consider that subperiosteal erosions of bones, especially in the phalanges or at the ends of long bones, are pathognomonic of hyperparathyroidism, whether primary or secondary.

Regarding the correlation of roentgenographic findings and morbid anatomy, the authors believe that rickets or osteomalacia, whatever the cause, indicates the presence of uncalcified osteoid tissue in bone, and roentgenographic changes of primary or of secondary hyperparathyroidism indicate the presence of generalized osteitis fibrosa (excessive osteo-

clastic resorption and replacement of bone by fibrous tissue).—*D. V. Campbell, M.D.*

Teall, C. G. Generalised softening of bone due to metabolic causes. III. Some observations on the radiology of Lignac-Fanconi disease and renal infantilism. *Brit. J. Radiol.*, Nov., 1954, *27*, 618–622.

The roentgenographic findings in 7 patients with Lignac-Fanconi disease are presented. This disease, more precisely called "cystine storage with aminoaciduria and dwarfism," is characterized by two essential features: (1) the presence of cystine crystals in the cornea, conjunctiva, lymph nodes, and bone marrow; and (2) aminoaciduria. The condition is of interest roentgenologically, because certain bone changes occur which are similar to those found in rickets.

Two of the patients showed no bone change. Four showed roentgenographic evidence of rickets, indistinguishable from that seen in simple rickets, and 1 patient presented a case of resistant rickets with marked osteoporosis that was believed to be a later stage of the disease.

The author alludes to his description in 1928 of the bone changes in renal infantilism in which he distinguished two groups, a "wooly type," the appearance of which in no way resembled that seen in simple rickets, and a second group in which bone changes resembled those of simple rickets.

From a review of the original series of his cases of renal infantilism which showed the bone changes resembling those of simple rickets, the author now feels that it is probable that these were cases of Lignac-Fanconi disease, not recognized as such in 1928. Therefore, he doubts that there are two different types of bone change in renal infantilism.—*Thomas F. Meaney, M.D.*

Swann, G. F. Generalised softening of bone due to metabolic causes. IV. Pathogenesis of bone lesions in neurofibromatosis. *Brit. J. Radiol.*, Nov., 1954, *27*, 623–629.

The author limits the discussion to one type of bone lesion seen in neurofibromatosis, namely osteomalacia. Although the association between neurofibromatosis and osteomalacia has been mentioned by several investigators in no case can a biochemical diagnosis be made. The author believes that there is much evidence for the association and has discovered 5 cases that have a characteristic biochemical picture. These fall into type 1 of Dent's classification of renal tubular disorders that are termed "renal tubular osteomalacia," and that Fanconi calls "phosphate diabetes."

There appears to be a congenital tubular defect for the reabsorption of phosphorus, whereby a low serum phosphorus level is constantly found with normal amounts of urinary phosphorus. When the serum phosphorus level is low, calcium is excreted in excess by the gut, and this leads to hypocalcification of osteoid tissue. Because these cases are vitamin D resistant, they require huge doses to bring about improvement.

The author presents 4 cases where there is association of neurofibromatosis and renal tubular osteomalacia, and in which the other accepted causes of osteomalacia have been excluded. He concludes that in all cases the osteomalacia has exactly the same pathogenesis, namely, a renal tubular defect with a phosphate leak.—*Thomas F. Meaney, M.D.*

Gimes, Béla, and Szendröi, Zoltán. Über die Bedeutung der Verschiebungen im Serumeiweissgehalt bei der Diagnose von Knochentumoren. (On the significance of the shifts in the serum protein fractions for the diagnosis of bone tumors.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, Nov., 1954, *81*, 567–582.

For the diagnosis of bone tumors roentgenographic examination still plays the leading role, although a number of clinical and laboratory observations are also being used. In some cases, however, all these techniques, even biopsy, may not lead to a definite diagnosis, notably in regard to the malignant or nonmaligant nature of the tumor.

The authors have investigated the value of studying the shifts of the serum protein fractions by means of the paper electrophoretic method of Novotny for the diagnosis of bone tumors. They made observations on 30 normal individuals, on 9 patients with benign bone tumors, on 21 patients with malignant primary and secondary bone tumors and on 9 patients with bone inflammations which might simulate sarcoma.

They found no characteristic deviation in the distribution of the protein fractions for benign tumors. Primary and secondary malignant tumors, however, as well as cases of bone inflammation produced pathognomonic changes in the electrophoretic patterns. The alpha-gamma quotient was smaller as compared to normal. For the malignant tumors the alpha-2 fraction and eventually the beta fraction were increased. For plasmocytes a sharp increase of the singe fractions is not only of diagnostic but also of prognostic singnificance. For inflammations the authors observed an increase of the gamma globulins on a broad basis with specific character. This fact permits a differentiation of the sarcoma from the various simulating forms of osteomyelitis.

The authors feel that the number of observations made is still too small to arrive at final conclusions but they think that the study of the shifts of serum protein fractions promises to become an important adjunct to roentgen examination in the diagnosis of bone tumors.—*Otto Glasser, Ph.D.*

Blood and Lymph System

Wetzel, Nicholas. Retrograde filling of the carotid system following vertebral angiography. *Quart. Bull., Northwestern Univ. M. School*, 1954, *28*, 379–381.

A case of retrograde filling of the carotid system during vertebral angiography is presented by the author as the first such report.

On attempted right carotid angiography of a thirty-two year old man having spontaneous subarachnoid hemorrhage, the vertebral artery was injected. The extracranial vertebral artery was outlined, as well as portions of the internal carotid, the anterior and middle cerebral arteries. A film of the cervical region on reinjection again outlined the vertebral artery, as well as the common and internal carotids, the subclavian artery, and the thyrocervical trunk. The cannula was withdrawn, the carotid punctured and a normal right carotid angiogram obtained.

Autopsy revealed multipe hemorrhagic areas within the brain, an intraventricular hemorrhage and a great deal of subarachnoid blood. No abnormality of the vascular system was found to explain the reflux filling of the carotid system so that its occurrence was felt to be the result of spasm of the vertebral or basilar artery.—*John F. Weigen, M.D.*

Aubaniac, R., Viallet, P., Sendra, L., Combe, P., and Chevrot, L. L'angiocardiographie par voie sous-claviculaire; comparaison avec les autres procédés d'injection. (Angiocardiography by the infraclavicular route; comparison with other methods of injection.) *Presse méd.*, Sept. 29, 1954, *62*, 1308–1311.

Injection into a *peripheral vein* has the advantage of simplicity, except when obesity requires an incision with the inevitable subsequent scar. In children, the jugular route or the incision necessitates general anesthesia, an added risk in cardiopathies. Moreover the radiopaque medium is diluted in the peripheral blood, which causes a delay in opacification, and makes interpretation more difficult by a persistent dextrocardiogram (visualization of the right heart) during the ensuing levocardiogram. Cardiac catheterization allows *paracardiac* (into the vena cava) *injection*, with good separation of right and left halves of the heart, but it is an involved procedure, comparable to major surgery, and therefore it cannot be repeated as often as desired. Excellent positive contrast films are also obtained by *intracardiac injection*, though the possible complications (injury of nodal tissue or coronary artery, myocardial tear) constitute a risk seldom justified for anything but emergency usage.

In 1952 Aubaniac introduced the percutaneous puncture of the subclavian vein as a substitute whenever the usual routes for transfusuion become inaccessible (young, obese, shocked, burned, amputated patients). In 1953 he suggested it as a routine procedure for angiocardiography. A thick needle, mounted on a syringe, is introduced horizontally (patient supine) in the medial portion of the space between the left clavicle and the first rib, the needle tip being directd toward the posterior aspect of the first chondrocostal junction. The needle must be perfectly immoblized during the injection (tears, injection into mediastinal tissues), and air-free channels must be assured (air embolism).

The procedure is said to be innocuous (for instance, intramediastinal injection has as only sequel a delayed urography), and may be repeated as often as necessary. It requires neither local (?) nor general anesthesia, leaves no scars, can be used in children over 6 months of age, and allows as good, or better, separation of the heart chambers on reontgen study as can be obtained with catheterization (the thicker needle allows faster injection of the contrast medium than the comparatively narrow catheter). Those who use angiocardiography on a large scale may find it useful to investigate the merits of the subclavian route.—*E. R. N. Grigg, M.D.*

Jordan, Alphonzo, Lawlah, John W., Johnson, John B., and Burton, Andrew F. Unsuspected superior vena caval obstruction detected by angiocardiography; report of a case. *Radiology*, Oct., 1954, *63*, 531–534.

The authors present a case of proved superior vena caval obstruction demonstrated by angiocardiography, though totally unsuspected clinically.

The case serves to point out how cardiovascular opacification studies have increased the accuracy of the diagnosis of upper mediastinal masses. These studies not only revealed the site of obstruction of the superior vena cava, but also showed obstruction of the left innominate and right subclavian veins as well as the elaborate collateral circulation by which blood entered the heart.

The conclusion was reached that the obstruction was gradual in onset and of longer duration than the history suggested, accounting for the absence of the classical superior vena caval obstruction syndrome. Thoracotomy revealed the obstruction as being due to a reticulum cell sarcoma in the right anterior superior mediastinum.—*Michael J. Healy, M.D.*

Gyllenswärd, Åke, and Lodin, Herman. The value of selective angiocardiography in the diagnosis of complete transposition of the great vessels. *Acta radiol.*, Sept., 1954, *42*, 189–195.

Preoperative knowledge of the anatomic disturbance in congenital heart disease is important for the surgeon. Thus, Bahnson and Ziegler are cited to the

effect that, in a large series of cyanotic patients, the mortality in the group in which the operation went according to plan was only half of that in the group in which unexpected anatomic findings were discovered.

The authors state that the combined use of cardiac catheterization and selective angiocardiography is more effective in preoperative diagnosis than either method alone. They report two examples of complete transposition of the great vessels.

In one case peripheral angiocardiography had been done elsewhere, and a diagnosis of transposition of the aorta with atresia of the pulmonary trunk had been arrived at. At necropsy a few months later complete transposition, with a patent pulmonary trunk, was revealed.

In the second case a peripheral angiocardiogram resulted in a diagnosis of Fallot's tetralogy with marked dextroposition of the aorta. At subsequent catheterization, selective angiocardiography was performed from the right ventricle and from the left atrium through a valve-competent foramen ovale. The right ventricle gave origin to the aorta, while the left ventricle gave origin to the pulmonary trunk, and a moderate amount of opaque material passed from the left to the right ventricle through a large ventricular septal defect, and into the aorta.

The authors also stress the fallibility of relying on rigid patterns in the routine roentgenograms: the shadow of the great vessels may be either broad or narrow in the posteroanterior view. Also, whereas the pulmonary vascular shadows are usually more prominent than normal, they may appear normal or less marked than normal.—*André Bruwer, M.B., Ch.B.*

Taveras, Juan M., Mount, Lester A., and Friedenberg, Richard M. Arteriographic demonstration of external-internal carotid anastomosis through the ophthalmic arteries. *Radiology*, Oct., 1954, *63*, 525–530.

In arteriograms obtained months after carotid occlusion in the neck, the authors have, in 4 cases, demonstrated anastomosis between the internal and external carotid arteries by way of the ophthalmic artery.

It is a known anatomical fact that small anastomotic branches exist between the external and internal carotid arteries. Four groups of these connecting channels have been described. Normally they are small and contribute very little to the circulation of the brain. Dandy has pointed out that reduction of the lumen of the internal carotid artery to one-half or less forces the collateral channels of the circle of Willis to enlarge and carry an additional load to the brain. It is reasonable to assume that similar enlargement of the anastomotic branches between the internal and external carotid systems by way of the ophthalmic artery may take place. In 1 case here reported, the ophthalmic artery was apparently carrying a large amount of blood, since it became two or three times larger on films after internal carotid ligation, and since unusually good filling of the intracranial arteries was observed.

Routine serialograms were necessary for study of this collateral circulation, since the blood flow was found to be somewhat slower than that through the internal carotid system.—*A. Ralph Watson, M.D.*

Willis, G. C., Light, A. W., and Gow, W. S. Serial arteriography in atherosclerosis. *Canad. M. A. J.*, Dec., 1954, *71*, 562–568.

Serial bilateral femoral arteriography was performed as a means of studying arteriosclerotic vessels during life. The second study was performed two to six months following the first.

The appearance of the vessels on different examinations was very similar, the atheromatous plaques that were visualized could always be identified on subsequent studies. Plaques were most common in the region of Hunter's canal and the upper popliteal artery. Those on deeper vessels were most easily identified and showed the more dramatic changes, while the shallow ones usually showed little change.

From the study it is evident that arteriosclerosis is not always a slowly progressive disease. Some of the intimal plaques may enlarge or become smaller, while others remain stationary. Regression and progression of plaques were never found coexistent in the same case. The authors feel those of a group treated with ascorbic acid showed improvement compared to an untreated group, as measured by the size of the plaques.—*John F. Weigen, M.D.*

Gould, David M., and Willson, James K. V. Abdominal aortography. *Am. J. M. Sc.*, Nov., 1954, *228*, 586–598.

Abdominal aortography is a dynamic roentgen method which demonstates the lumen of the vascular system by the injection of radiopaque contrast substances into the circulation. Recent advances in vascular surgery have given impetus to further development of this technique. It was first performed by a Portuguese urologist named Reynaldo dos Santos in 1927, who performed 431 transvertebral abdominal aortograms and reported that this method was quite safe. The technique later fell in disrepute in the United States due to experiments on dogs by Henline and Moore who claimed that the method was hazardous, causing permanent vascular damage in some cases. In 1942 Nelson and Doss studied the technique more intensively and since then the method has become increasingly popular.

Abdominal aortography is an excellent method for demonstration of vascular abnormalities of the aorta and its branches. Congenital anomalies, aberrant vessels, ectopic vessels, arteriovenous fistulae, aneurysms, thrombi, emboli, stenoses,

occlusions, Leriche syndrome, collateral circulation, arteriosclerosis and thromboangiitis obliterans can be readily demonstrated. Aortography also lends itself well to the diagnosis of kidney disease, especially in such conditions as aplasia, hypoplasia, aberrant vessels, ectopia, duplication, horseshoe kidney, urinary stasis, hydronephrosis, ureteropelvic obstruction, calculus, tuberculosis, polycystic kidneys, cysts, neoplasm, infarct, and the "Goldblatt" kidney. The procedure can also be used to study the vascularity of other abdominal and pelvic organs such as spleen, liver, adrenal, ovary, uterus and bladder as well as abnormalities in the paraortic and retroperitoneal regions.

The patient is examined in a fasting state with appropriate premedication. The prone position is used. A needle is inserted into the aorta, 10 to 30 cc. of sodium urokon injected and a roentgenogram is taken at the end of the injection and seven seconds later. The level of the injection is varied according to the main point of interest.

In recent years very few fatalities have been reported, most of them due to either renal damage or hemorrhage from the puncture site.—*William C. MacCarty, Jr., M.D.*

Wachtler, F. Zur Röntgensymptomatologie der Hämangiome der quergestreiften Muskulatur. (Roentgenologic findings in hemangiomas of the striated muscles.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, Oct., 1954, *81*, 508–513.

Various roentgen findings were observed in a twenty-eight year old patient, who had noticed a mass progressively increase in size on his forearm since early childhood.

A conventional film showed an increase in the soft tissue components and numerous calcific foci in the involved area. The calcifications were arranged in bizarre nodular, linear, and serpiginous forms. The adjacent bone presented areas of cortical atrophy, osteophytes, and medullary sclerosis. Serial phlebograms showed numerous subcutaneous, venous channels and poorly opacified deep veins with defects in their walls. A widespread venous plexus was seen around the calcific foci, between which were cloudy collections of contrast material, indicating the high vascularity and the infiltrating nature of the tumor. The calcifications either arose from multiple thrombi or degenerated muscle fibers. Occasional areas of ossification were also noted.

It is suggested that, in the absence of varicose veins, phleboliths are pathognomonic of muscle hemangiomas.—*Joseph Zausner, M.D.*

General

Hilbish, Theodore F. Developments in diagnostic radiology. *Pub. Health Rep.*, Nov., 1954, *69*, 1017–1027.

Developments in the use of the roentgen-ray beam and other forms of radiation and equipment for utilization of these developments, together with development of contrast media, has widened the usefulness of diagnostic roentgenographic procedures.

One of the new roentgenographic methods being studied at the Clinical Center at the National Institutes of Health, Bethesda, Maryland, is serialographic ureterography. This consists of films exposed every two seconds for a total of twelve films following the administration of intravenous urokon. Such a study makes possible demonstration of peristaltic activity of the ureter. It has the advantage of being a physiological method of study as opposed to the retrograde method. The usefulness of the method cannot yet be evaluated because of the relatively few cases in which it has been employed. However, in 2 patients, minimal ureteral strictures have been recognized.

The Schönander biplane angiocardiographic unit makes possible simultaneous filming in two planes with serial films being exposed as rapidly as six films per second. This makes possible the study of aortograms, splenograms, cerebroarteriograms, and angiocardiograms with minimal injections, and with the advantage of being able to compare films in two planes taken simultaneously.

The Phillip's fluorescent image-intensifying tube provides an intensification factor of 1,100 times. This makes possible photography of the fluorescent image with a quantity of radiation exposure to the patient which is within the safe limit. In its present form, however, the equipment is quite unwieldy and requires binocular vision. Westinghouse X-ray Corporation has produced a more maneuverable unit of this type with a 5 inch viewing screen which is commercially available. Although the equipment is also limited in its usefulness because of the difficulty of maneuvering and the small size of the viewing screen, fluorescent image intensification will undoubtedly play an extremely important role in diagnostic and experimental roentgenology within the next few years.

Another relatively new development in diagnostic roentgenology is the use of a bronchoscope as a means of passing a needle under direct vision through the carina and into the left atrium, in order to determine left atrial pressure. After pressure studies have been made, a contrast substance can be injected directly into the left atrium and roentgenograms taken determine the size of the cardiac chamber. This may make differentiation between mitral stenosis and mitral insufficiency possible, but the use has been too limited to know whether this will be practical.

Another development in the use of contrast media is the use of dionosil in either aqueous or oily solution in bronchography.

Xeroradiography is a new procedure under investigation which involves the use of a chemically coated aluminum plate, charged electrostatically,

and then exposed to radiation. The charge is dispersed in direct proportion to the intensity of the radiation. A fine powder dusted on the charged plate adheres in greatest quantity to those areas carrying the greatest charge, hence the formation of a roentgenographic image. This may have value in public health use.

A French investigator stimulated interest in color roentgenography during the First World War but the subsequent investigations have proved this to be somewhat of a hoax. More recently, however, the interest has been restimulated and it remains to be seen whether reliable or beneficial results in this field can be obtained.

Two isotopes, thulium-170 and xenon-133, have recently been utilized as a source of energy for diagnostic radiology. Portable sources weighing less than 7 pounds have been constructed. These will certainly not replace diagnostic roentgenographic equipment but it is conceivable that such small portable roentgen-ray units may have practical value in localities where roentgenographic equipment is not available.

The almost constant improvement of electronic devices and equipment will inevitably alter the future diagnostic, and for that matter, therapeutic, applications of roentgenologic equipment. For example, with the so-called "storage tube" it is possible to examine fixed objects by using very short roentgenographic exposures and then to store the resultant picture on the grid of the storage tube.—*Lois Cowan Collins, M.D.*

RADIATION THERAPY

Paterson, Ralston, and Paterson, Edith. Hodgkin's disease. *Brit. M. J.*, Dec. 4, 1954, *2*, 1315–1318.

The authors present a summary of Hodgkin's disease pointing out that clear-cut differentiation from other diseases of the lymphoreticular group is not always possible. Histopathologically the disease resembles the sarcomas and on occasion may terminate as a reticulosarcoma.

Although the middle-aged adult is usually the victim, the very young as well as the aged may be affected. The authors, however, have not seen a patient with Hodgkin's disease under two years of age.

Definite diagnosis requires biopsy. Clinically discrete, movable, enlarged lymph nodes in the cervical regions are a common, early manifestation. Although abdominal lymph node enlargements may be found on examination and lymphadenopathy suspected from the chest roentgenogram, only occasionally are gastrointestinal symptoms or dyspnea heralding complaints.

Progressive involvement of other lymph nodes and splenic enlargement are the rule. The onset of intolerable itching may occur with retroperitoneal lymph node involvement. Pleural effusion usually occurs with involvement of the lung. Foci in bone may cause pain before roentgenographic evidence of involvement appears.

In addition to its diagnostic use, the excision of a localized lesion may provide a therapeutic approach. The authors doubt that surgery has any more enduring effect than irradiation, which has become the mainstay of treatment. Since repeated irradiation becomes necessary as new foci develop, the smallest dosage to control the lesion under treatment and the longest possible interval between courses of therapy are desirable. A potentially curable lymphosarcoma or reticulum cell sarcoma must be excluded before planning a moderate amount of irradiation for localized lesions.

Nitrogen mustard (NH_2) causes prompt relief of systemic manifestations and lymph node enlargements. Triethylene melanine (T.E.M.) in oral dosage of 0.25 mg./kg. (average 5 mg. daily for three days) produces similar results, less rapidly but with less side reaction. Hematopoietic suppression is a constant threat. Treatment, therefore, should not be repeated more often than six weeks to two months and should be carefully regulated by blood count findings. It is the authors' opinion that roentgen therapy should be used first, since remissions are longer and hematopoietic tolerance is better with this modality. When response to irradiation lags or the disease becomes generalized, chemotherapy may be instituted. In generalized disease supplementary irradiation may be directed to an obvious mass. Treatment of the early case both with irradiation and with chemotherapy, however, has not increased survival.

Cortisone or ACTH has not had sufficient trial for complete evaluation, but some temporary benefit has been observed in the otherwise terminal case.

Pregnancy contraindicates irradiation to abdomen or groin regions. The advisability of interrupting the pregnancy or of deferring the treatment to these areas until following delivery must be determined.

Although Hodgkin's disease eventually is fatal, much can be done. The authors' five year survival experience for disease initially localized was 51 per cent, and for those initially generalized 15 per cent. The over-all survival of the two groups was 25 per cent, in a series of 256 patients treated between 1934 and 1947.—*Thomas B. Efford, M.D.*

Scholte, P. J. L., Kok-v. Alphen, C. C., and Combée, B. Treatment of the cornea with a new Lilliput roentgen tube. *Acta radiol.*, Oct., 1954, *42*, 316–328.

The authors describe a tube which "is probably the smallest ever designed" in a paper from the Muncipal Hospital, Hague, and the laboratories of N. V. Philips, Eidhoven, Netherlands.

The tube is 45 mm. long and 14 mm. in diameter. The maximum tube voltage is 25 kv. and maximum

tube current is 200 microamperes. The jacket is of metal and is grounded. The distal end of the tube is of beryllium coated with gold which acts as a rather large target (6.5 mm. in diameter); thus target-skin distances of 1 mm. are possible. The cathode is of tungsten and is surrounded by a charged metal shield which acts as both a focusing device and as insulation from the grounded jacket. The high voltage is attached to the cathode only.

The half-value layer obtained at 25 kv. is 0.035 mm. of aluminum or 0.5 mm. of tissue and at 10 kv. it is 0.02 mm. of aluminum. Dosage rate is 8,500 r per minute at 1 cm. from the focus at 25 kv. and 200 microamperes; at 10 kv. it will give 2,600 r per minute; and at 1 mm. from the focus dosages of some hundred thousands of r per minute are obtained. Depth dose charts are given for 1 mm. focus-skin distances. Even at 50° from the vertical, the variation in dosage at the surface is negligible.

Rabbits' corneas were treated with varying doses of radiation. Total doses of 30,000 r given in 4 treatments in 2 weeks showed no damage with this unit. Local changes occurred with doses over 30,000 r. In rabbits treated with the Philips contact unit with half-value layer of 0.37 mm. of aluminum, 16,000 r gave cataracts in all cases.

In humans the treatment of 100 corneas by various contact and superficial units is summarized. These include some keratitis but mainly corneal transplants treated to reduce vascularization. In the latter, best results are obtained when vascularization is at its peak. Dosages varied from 200 r to 3,400 r, usually divided into 4 doses in two weeks. Favorable results were obtained by all methods but the authors feel that this "Lilliput tube" is easier to handle because of its small size.—*Henry J. Klos, M.D.*

Windeyer, B. W. Cancer of the thyroid and radiotherapy; Mackenzie Davidson Memorial Lecture. *Brit. J. Radiol.*, Oct., 1954, *27*, 537–552.

This article is a review of thryoid carcinoma and has as its basis 157 cases seen at the Middlesex and Mount Vernon Hospitals from 1936 and 1940 to 1953, respectively. The series includes only those patients referred for radiation therapy.

The ratio of women to men was 2.5 to 1. A history of goiter was obtained in 23 cases but may have been present in more. Thyrotoxicosis was associated with the carcinoma in 4 cases but myxedema was not a presenting symptom in any.

It was possible to check the histopathological classification in 118 cases. About half had undifferentiated carcinoma, and one-fourth each had alveolar adenocarcinoma and papillary adenocarcinoma. There were 2 Hürthle cell carcinomas and 1 fibrosarcoma.

There were 32 papillary adenocarcinomas and they showed the usual slow evolution and generally good prognosis. The presenting clinical picture in 8 cases was a mass in the thyroid, in 13 cases masses were present in the cervical region only, and in 3 cases both thyroid and cervical masses were present. Eight patients presented themselves with local recurrence and 1 had a spinal metastasis with paraplegia.

There were 26 cases of alveolar adenocarcinoma and the evolution of the disease in these varied with the degree of differentiation. Frequently distant metastases were the cause of the presenting symptoms. This was true in 8 cases, bones being particularly involved. Lymph node metastases were a late phenomenon.

The undifferentiated carcinomas numbered 57 and represented the most malignant group. Those lesions showing marked pleomorphism and numerous irregular multinucleated giant cells were the most virulent. These occasionally grew no rapidly that there was a visible increase in size in two or three days. Ths skin sometimes was red and edematous and local involvement was early and rapid. Generalized metastases also occurred early but the local symptoms usually distracted one's attention from them.

The radiation therapy consisted almost entirely of roentgen therapy with a quality of the beam between 2 and 3.5 mm. Cu half-value layer. When the disease was localized, the fields were individualized in an attempt to give from 4,500 to 5,000 r tumor dose in about five weeks. This is often difficult to do. In the more diffusely infiltrating growths, larger fields, on the order of 10 by 15 cm., were used and an attempt was made to give 3,000 to 3,500 r in five weeks to the tumor.

In the cases in which five year survival could be determined, there was an over-all survival rate of 37 per cent. Because of the well known prolonged courses of both papillary and alveolar adenocarcinomas, this figure is meaningless; but the 28.5 per cent (8 cases) five year survival in the undifferentiated group, the author considers significant.

The author states that papillary adenocarcinoma satisfactorily treated by roentgen therapy requires a large dose and therefore if surgical removal is thought to be complete, postoperative irradiation should not be done. Response by alveolar adenocarcinoma to roentgen irradiation is, in general, rather poor even at high dosage, but irradiation is useful as a palliative measure. Undifferentiated carcinoma will respond to irradiation in about 50 per cent of cases.

A few cases of well differentiated alveolar adenocarcinoma treated with I^{131} are discussed, including those with metastases. These latter took up the iodine after ablation of normal thyroid function by surgery, thiouracil and/or I^{131}. One complication of therapy with radioactive iodine occurred when a patient drank the solution with her dentures still in place. Iodine was absorbed in the plastic and formed

2 hot beta-ray applicators causing a fibrinous reaction on the mucosa of her mouth.—*Henry J. Klos, M.D.*

Boyd, David P., Smedal, Magnus I., Kirtland, Howard B., Jr., Kelley, Gurney E., and Trump, John G. Carcinoma of the lung; a report of 403 cases. *J. Thoracic Surg.*, Oct., 1954, *28*, 392–411.

The authors present their experiences in the 403 patients with carcinoma of the lung seen in the Lahey Clinic during the past 15 years. In the clinical study of these patients, it was found that 374 patients were asked about smoking and 82 per cent smoked. The chest roentgenogram was the most consistently accurate diagnostic tool with the diagnosis being indicated by the radiologist in approximately 90 per cent of the cases. Cytological study was positive in 50 per cent of the 117 cases in which it was attempted. Bronchoscopy was carried out in 312 cases and it was clinically positive in 61.8 per cent, but biopsy was positive in only 42 per cent of the 312 cases.

Histopathological study in 301 cases showed 45 per cent squamous cell carcinoma, 30 per cent undifferentiated carcinoma, 14.6 per cent adenocarcinoma, 10 per cent carcinoma simplex and 0.7 per cent alveolar cell carcinoma.

Exploratory operations were carried out in 217 (53.8 per cent) of 403 patients. Accepted criteria of inoperability were used; *i.e.*, extension to or fixation of the carina, distant metastases and pleural fluid positive for tumor cells. In some cases, high voltage roentgen therapy (2 million volt) was used in an attempt to make inoperable lesions operable; and in a few patients, epidermoid carcinomas were shrunk down so that the carina was no longer involved. The surgery was interposed midway along the course of radiation therapy. More recently the total dose of radiation, up to 6,000 r has been given before operation which is carried out one to two months following irradiation. The authors do not seem impressed with their preliminary experience with irradiation in carcinoma of the lung. Of the total cases of carcinoma of the lung, only 25.8 per cent was submitted to resection.

Fifteen patients lived five years or more. This is a 9.4 per cent five year survival. Included in the 15 is 1 case which received roentgen therapy alone. This patient, however, is reported to be in failing health now from metastases. Of the other 14 patients, 1 died of recurrence at $5\frac{1}{2}$ years and 2 who are alive are believed to have recurrent tumor.

Patients who had an exploratory operation alone lived an average duration of 5.1 months. Those who had exploration plus irradiation survived 12.6 months. All of those who had resections lived an average of 27.9 months.—*Paul C. Olfelt, M.D.*

Larsson, Lars-Gunnar, and Mortensson, Gunnar. Carcinoma of the paranasal sinuses and the nasal cavities; a clinical study of 379 cases treated at Radiumhemmet and the Otolaryngologic Department of Karolinska Sjukhuset, 1940–1950. *Acta radiol.*, Aug., 1954, *42*, 149–164.

Treatment of malignant tumors of the paranasal sinuses and nasal cavities is largely centralized in Sweden; therefore, there is an unusual opportunity to study a large number of cases. The radiation therapy in the cases reported in this article was done at Radiumhemmet and the surgery at the Otolaryngologic Department of Karolinska Sjukhuset.

The report is limited to cases of carcinoma arising from the mucosa of the nasal cavities or paranasal sinuses. A total of 379 patients were seen between 1940 and 1950. The age distribution was of the usual "cancer group," almost all being between forty and eighty years of age. There was almost an equal number of men and women.

The maxillary sinuses are by far the most frequent site of primary involvement, some carcinomas occurring in the ethmoid sinuses, and rare carcinomas occurring in the frontal and sphenoid sinuses.

Early symptoms are those of infection, that is pain, purulent nasal secretion and nasal obstruction. More definitive signs are usually those of invasion and include swelling of the cheek, sanguineous nasal discharge, and symptoms from invasion of the orbit or oral cavity (such as loosening of the teeth). There were roentgen findings in all cases, in 90 per cent there being evidence of bone destruction and in 10 per cent there being only increased density of the soft tissues. This is accepted as an indication of late diagnosis, but pessimism is expressed that diagnosis can be made early because of the similarity of symptoms to infection. Some of the earliest diagnoses in this series were made by microscopic examination of tissue removed during surgery on the nose and sinuses.

Therapy consisted largely of preoperative irradiation with roentgen rays of approximately 1.0 mm. Cu half-value layer, followed by surgery (if considered operable) and insertion of radium tubes. A full course of irradiation to antral tumors was carried out by using 4 fields, each receiving a skin dose of 3,000 r in 30 days. The anterior fields usually extended from the upper lip to above the eyebrows, the contralateral field being angled toward the tumor, and both lateral fields being centered to include the entire tumor. The eyes were protected with lead, except that on the tumor side the eye was not shielded until 1,000 r had been given, or not at all if the orbit was invaded. All parts of the antrum were calculated to receive between 6,000 and 7,000 r. A dry epithelitis resulted.

The radium therapy consisted of the insertion of 4 tubes, each containing 50 mg. of radium and fil-

tered by 0.3 mm. Pt. 0.35 mm. Au and 3.0 mm. Al. These were left in place for 3 to 5 hours. Each tube was calculated to give 200 r per hour at 1.7 cm. from the center of the tube.

Surgical therapy consisted of electrocoagulation of tissues and removal of the pieces with forceps. This was usually done through the mouth when the antrum was involved.

The results of therapy are difficult to evaluate because of the variable manner in which it was applied. At the beginning of the series less than maximal irradiation was given, followed by surgery and radium insertion. Later, full irradiation was given followed by surgery. Then, because a significant number of cases showed no residual tumor after full external irradiation, surgery was done only when there was evidence of recurrence. The authors state that there is now evidence that better results are obtained with full irradiation and surgery to be done before recurrence.

The absolute five year cure rate for the entire series was 23 per cent (27 per cent for the treated cases). The five year cure rate for those receiving irradiation plus surgery was 45 per cent (51 cases). The rate for patients receiving irradiation alone was 12 per cent (17 cases) but only 9 per cent if the few operable cases not operated upon are excluded.

Complications included 11 per cent mortality in the postoperative period, usually due to cerebral infection. Cutaneous changes due to radiation therapy were minimal. There was unilateral cataract in 10 per cent of those living over five years (5 cases). Atrophy with dryness and crusting of the nasal mucosa was the most significant complication of radiation therapy.—*Henry J. Klos, M.D.*

White, George, Sieniewicz, James, and Christensen, William R. Improved control of advanced oral cancer with massive roentgen therapy. *Radiology*, July, 1954, *63*, 37–42.

Intraoral cancer, even though advanced, presents a therapeutic challenge since the disease remains local and regional for a long time. Metastatic lymph nodes of the neck are often amenable to treatment in spite of the advanced state of the primary lesion. Treatment of the involved lymph nodes must await a reasonable assurance that the primary cancer has been eradicated.

In an attempt to improve results, the authors gave tumor doses much higher than the conventional 6,000 r. They decided to go as high as 12,000 r and to modify this figure whenever necessary to eradicate the disease in the mouth. This dose was attained by the use of an intraoral cone plus multiple external portals.

Approximately half the total dosage was delivered through the intraoral portal, and the rest was given through several external portals. They gave a daily intraoral dose of 400 r (in air) plus 200 r (in air) through one of the external portals alternately. The tumor dose through the intraoral portal ranged from 4,000 to 6,000 r. They used the largest cone that could be tolerated. Complete coverage of the entire tumor, plus margins of normal tissue, was attempted but was not considered essential. After the intraoral therapy was completed, the rest of the dose was given through lateral and submental external portals. The quality of the roentgen rays at 250 kv. was 1.4 mm. Cu, half-value layer.

One hundred and thirty-seven patients with cancer of the mouth were treated between 1944 and 1951. Fifty-four (39 per cent) of the patients received conventional therapy (less than 7,000 r). Massive dose (more than 7,000 r) was administered to 83 patients (71 per cent).

Marked improvement in the control of advanced intraoral cancer was noted when massive roentgen dosage was used. The optimum tumor dose appeared to be in the range of 9,000 to 10,000 r, delivered over a period of about four weeks. This dosage schedule gave the highest rate of local tumor control without significant increase in radiation sequelae.—*A. W. Sommer, M.D.*

RADIOISOTOPES

Seed, Lindon, and Jaffe, Bertha. Comparison of the tracer dose and the therapeutic dose of I^{131} as to thyroid uptake, effective half-life, and roentgen dosage. *Radiology*, Oct., 1954, *63*, 551–561.

The authors have made a comparison with respect to the uptake and effective half-life of the tracer dose and the therapeutic dose of I^{131} in 91 patients with hyperthyroidism. They administered a tracer dose of 40 μc. of I^{131} to each patient. A twenty-four hour thyroid uptake was determined by using a bismuth cathode counter at a far distance. The thyroid gland was checked for radioactivity at three day intervals. The effective half-life was calculated from these data.

Similar measurements were made after the administration of therapeutic doses of I^{131}. Lead absorbers were placed over the bismuth cathode counter to reduce the counting rate when measuring such large quantities of radioactivity.

The thyroid uptake of the tracer dose is compared with that of the therapeutic dose for the patients with toxic diffuse goiter. There were some extreme variations but, by and large, the thyroid uptake and the effective half-life of the therapeutic dose followed that of the tracer dose with reasonable predictability.

An analysis was made of the clinical results as related to the dosage, in equivalent roentgens, in the patient with toxic goiter. The median dose for optimal results is in the neighborhood of 10,000 rep. The median optimal dose calculated in terms of the uptake of the gland is in the neighborhood of 100 μc.

per gram. The correlation of dosage and result seemed no better than that obtained by simply calculating the dosage on the basis of the thyroid uptake of the tracer dose and the estimated weight of the gland.—*A. W. Sommer, M.D.*

Lindsay, Stuart, Dailey, Morris E., and Jones, Malcolm D. Histologic effects of various types of ionizing radiation on normal and hyperplastic human thyroid glands. *J. Clin. Endocrinol. & Metabol.*, Oct., 1954, *14*, 1179–1218.

Fifty-eight normal and hyperplastic human thyroid glands which had received various forms of ionizing radiation were examined histologically. These included toxic diffuse and toxic nodular goiters, treated because of their hyperfunctioning status with either radioactive iodine, external irradiation, or implanted radon seeds. Seven normally functioning thyroids had been irradiated because of carcinoma of the thyroid or of surrounding organs, five with roentgen rays and two with cyclotron-produced neutrons. The radiation delivered ranged from that received from 470 microcuries of radioiodine up to that from 50 millicuries of radioiodine, with intermediate equivalent doses from roentgen rays, radon seeds, and neutrons. The time delay between first irradiation to obtaining of the specimen ranged from twelve days to twenty one years. Thus, a rather comprehensive picture of radiation injury and recovery following a variety of irradiation conditions can be pieced together.

The lesions observed were qualitatively similar, regardless of the type of irradiation. High dosage resulted in acute epithelial injury, associated with necrotizing vasculitis and thrombosis, eventually followed by follicular atrophy accompanied by perifollicular fibrosis. Changes believed due to overstimulation and exhaustion of the surviving thyroid cells consisted of the presence of bizarre epithelial forms in the recently irradiated specimens, a high incidence of Hashimoto thyroiditis after some months or years, and in two of the glands the late development of multiple Hürthle cell adenomas. These late proliferative changes suggest that thyroid carcinomas may develop in human hyperplastic thyroid glands after long periods following irradiation.—*R. Kenneth Loeffler, M.D.*

Allen, Willard M., Sherman, Alfred I., and Arneson, A. Norman. Carcinoma of the cervix; results obtained from the irradiation of the parametrium with radioactive colloidal gold. *Am. J. Obst. & Gynec.*, Dec., 1954, *68*, 1433–1446.

Previous animal experimentation had demonstrated that colloidal radioactive gold exhibited properties suitable for parametrial injection. It has a short half-life, 90 per cent of its activity is in the form of beta rays and the colloid is filtered out by the reticuloendothelial system of lymph nodes.

The authors applied this method to humans in carcinoma of the cervix, mostly clinical Stages I and II. Their work was done at Washington University. The addition of diodrast to the radioactive material showed on subsequent films that volumes of solution of from 30 to 40 cc. injected in each parametrial area diffusely infiltrated the entire parametrial area and node bearing regions; measurements with a scintoscanner indicated that the material remained localized in these areas.

In 24 cases in which Wertheim hysterectomy and pelvic lymphadenectomy followed injection of 50 millicuries of radiogold, the intensity of irradiation from the beta source was measured in the various groups of lymph nodes in the pelvis. The obturator lymph nodes received from 8,400 rep to 99,000 rep. The smallest doses were received by the upper iliac lymph nodes, these varing from 4,400 rep to 15,000 rep.

The gamma contribution was determined to be about 1,200 r to the cervix, bladder and rectum and 2,200 r to the mid-parametrium.

The authors attempt to evaluate their results. A total of 116 patients have received radiogold since 1950. Concomitant therapy included radical surgery, radical surgery and radium or radium alone. This was further complicated by the selection of patients for minimum operative risk in those receiving surgery.

Compared to their patients receiving radium and roentgen therapy alone, the authors believe that surgery (Wertheim hysterectomy and lymphadenectomy) plus parametrial injection of radiogold give better results especially in Stage II cases although there were only 37 Stage II cases so treated and the follow-up is less than two years in 31 of them. A few patients with Stage III lesions were treated and it would appear that the procedure might be of aid when combined with radium application.—*Henry J. Klos, M.D.*

Mellink, J. H. A 20 curie telecobalt unit. *Acta radiol.*, Oct., 1954, *42*, 305–315.

This is a description of a 20 curie cobalt unit designed and installed at the Academic Hospital of Leiden University, Holland. The unit is capable of handling 100 curies.

The head weighs over 900 kg. and consists of two concentric spheres. The outer sphere is made of steel-encased lead and the inner is of lead alone. The cobalt is within the inner sphere which is capable of rotating through 180° by means of a motor. When the head is rotated up into the off position, 19.5 cm. of lead is introduced into the path of the beam. The head can be rotated in its vertical axis manually and is moved vertically and about its horizontal axis by means of motors.

Small source-skin distances are used because of the small output (5 r per minute at 25 cm.). Two applicator cones are available, giving a choice of 15.5 cm. and 25.0 cm. source-skin distances. The cones are only 1.0 cm. from the skin and contaminating electrons are removed by closing the cone opening by 1 mm. of aluminum and placing 1 cm. of aluminum between this diaphragm and the patient's skin.

Some depth dose data in a masonite phantom are given. They correspond well with theoretical calculations using the "F" factor.—*Henry J. Klos, M.D.*

Shoch, David, and Puntenney, Irving. Ionizing radiation cataracts. *Quart. Bull., Northwestern Univ. M. School*, 1954, *28*, 359–363.

The first occurrence of cataract following ionizing radiation is recorded in the minutes of the thirty-second meeting of the Opthalmologic Society held in Heidelberg in August, 1905.

The investigation of the mechanism of production of these cataracts received an enormous impetus when casualty commissions began to examine the survivors of the atomic blasts over Hiroshima and Nagasaki and found an appreciable incidence of cataracts.

The present work was directed to eliciting the morphologic changes in the ciliary body of the rabbit's eye following irradiation and the relationship of these changes to cataract formation. By means of various types of lead shields, the whole eye or various portions thereof were irradiated, a 200 kv. therapy machine being used as a source of the radiation.

In essence it was found that the histopathologic changes produced in the ciliary body by radiation were transient in nature, and that exposure of the ciliary body *alone* did not produce cataracts, but that it was necessary to irradiate the periphery of the lens.

Investigation was then directed to the role of the ciliary body along physiologic rather than anatomic lines, that is, whether radiation caused an alteration in the permeability of the blood vessels of the ciliary body and whether there was an interference with the secretory function of the ciliary epithelium. The right eye of a group of rabbits was irradiated (each received 4,000 r) and at varying intervals of time thereafter 3 microcuries of I^{131} were injected intravenously. Twenty-four hours later paracentesis of both eyes was performed and the radioactivity of the aqueous humor in the two eyes (the left as a control) was measured by means of the conventional flow counter. No significant difference was noted in the pH studies of the aqueous humor of the two eyes. Likewise, the studies with I^{131} showed no appreciable change in the permeability of the ciliary body as far as I^{131} is concerned after a period of six weeks.

The authors therefore conclude that the permeability of the blood vessels of the ciliary body to I^{131} is altered only temporarily by ionizing radiation and its function to produce an aqueous humor more alkaline than blood is unaltered. In all probability the ciliary body plays a minor role in the production of radiation cataracts; the latter apparently result from direct damage to the lens itself. The concept of radiation cataract being a nutritional cataract is untenable.—*C. N. Borman, M.D.*

Davis, A. K., Alpen, E. L., and Sheline, G. E. The combined effects of thermal burns and whole-body x irradiation. II. Anemia. *Ann. Surg.*, Nov., 1954, *140*, 726–735.

It has been demonstrated that sublethal doses of radiation reduce the amount of burn area required to kill 50 per cent of rats exposed to radiant thermal energy. In mice, pigs, and dogs, irradiation superimposed upon thermal damage produces an increased mortality. This increased mortality associated with the combined injury is well documented, but the altered physiology resulting from the trauma has not been clearly defined even though infection has been shown to be of considerable importance.

This study was undertaken to delineate the severity and the extent of the anemia accompanying the combined injury to thermal ionizing radiation in the rat and to compare the anemia with that produced by the single trauma. Female rats were used for the study and comparisons were made on the effects of 25 per cent and 15 per cent body area burns, and 100, 475 and 500 roentgens of total body roentgen irradiation with the effects of three combinations of these on blood volume, red cell volume, hematocrit, red cell count, hemoglobin and reticulocyte values.

Irradiation was given by exposure to reontgen rays generated at 250 kv. (peak), 15 ma. with 0.5 mm. Cu and 1 mm. Al filter, corresponding to a half-value layer of 1.5 mm. Cu. Thermal injury was produced by a Mitchell-Nelson carbon arc exposing the anesthetized animal behind an asbestos aperture.

Both 15 per cent and 25 per cent body area burns produced an increased blood and plasma volume over the thirty day period studied. The red cell volume was not appreciably altered after the fifth day, but a slight deviation in hematocrit, hemoglobin and red count was observed throughout this period. The sustained reticulocytosis of the burned rat with concurrent normal red cell volumes indicated an accelerated destruction of erythrocytes during the post-burn period.

The dose of 100 r of ionizing radiation produced only a transient depression of the reticulocyte level. However, 500 r caused a severe anemia, with a concurrent fall of all the measured values for fifteen days. Such a combined injury produced an anemia which developed more rapidly than that

caused by 500 r alone. The anemia of the combined injury series was detectable on Day 8, and on Day 11, and was equal to the maximum observed in the irradiated animals on Day 15.

The erythrocyte values in rats given a 25 per cent burn and 100 r, more closely approximated the values of the burned than of the 100 r irradiated rats. Of the measured values the reticulocyte count proved to be the only useful indicator of exposure to ionizing radiation in this low dosage. Even the fall in this variable was observed by the fifth day in the reticulocytosis characteristics of the burned rat.—*Frank J. Rigos, M.D.*

Tullis, John L., Lamson, Baldwin G., and Madden, Sidney C. Pathology of swine exposed to total body gamma radiation from an atomic bomb source. *Am. J. Path.*, Jan.-Feb., 1955, *31*, 41–71.

The appearance and progression of lesions occurring in swine after exposure to approximately 700 r gamma radiation from an atomic bomb source are described in this study. The possible sequence of tissue damage and repair after atomic bomb radiation in man may be estimated from these observations in swine because the general level of radiosensitivity, the terminal picture following lethal exposure, and the size of the experimental animal all approximate those of man. Following exposure, animals were sacrificed at 4, 8, and 16 hours; 1, 1½, 2, 2½, 3, 3½, 4, 5, 6, and 7 days after radiation. No animal not killed lived spontaneously beyond 7 days.

The earliest lesions noted were mitotic arrest and necrosis of lymphoid cells and necrosis of small intestinal epithelium, both well established in four hours. There was a partial resumption of mitotic activity after eight hours which decreased after the first day. Following a quiescent period beginning repopulation of lymphoid organs with lymphoid cells was noted on the 3rd day, but this did not proceed far before death of the swine. Large mononuclear phagocytes were active in areas of lymphoid destruction during the first 24 hours, but not in the preterminal period.

Hematopoietic cells of the marrow began to diminish by 8 hours and continued to decrease steadily without evidence of regeneration before death. The erythroblasts were the most sensitive, followed by the myeloblasts and then the megakaryocytes. Terminally, the marrow was depleted of nearly all hematopoietic cells except the primitive reticular cells.

There was early damage to the epithelium lining, the basal mucosal glands of the small intestine and to the lymphoid elements. The epithelium was rapidly repaired being complete in one day. Plasma cells tended to replace many of the lymphocytes in the lumina propria.

In the testes the radiation injury was limited almost entirely to the destruction of spermatogonia. Evidence of radiation injury was minimal or absent in the ovary.

The late stage of injury was characterized by multiple hemorrhages throughout the body, both into the tissues and into the lumina of hollow viscera. Ulcers in the mucosa of the alimentary tract were frequently found.

In the pigs dying spontaneously terminal invasion and growth of bacteria were prominent features. Pulmonary edema was a complicating factor.

The more rapid development of lesions and the shorter course of the disease with fatal termination observed in gamma irradiated swine suggested that the "radiated effectiveness" was greater than in the previous studies of roentgen irradiated swine. The type and sequence of organ and tissue injuries in the swine exposed to the gamma radiation from an atomic bomb are similar to those following 600 r total body roentgen irradiation from a 2,000 kv. source.—*Frank J. Rigos, M.D.*

Sinclair, W. K., Trott, N. G., and Belcher, E. H. The measurement of radioactive samples for clinical use. *Brit. J. Radiol.*, Oct., 1954, *27*, 565–574.

The general principles of the dosimetry of artificial radioactive isotopes are now well known. The main factors of concern in the calculation of dosage where isotopes are administered internally are: (1) the assessment of uptake, (2) the rate of elimination, and (3) the inhomogeneity of distribution of the material in the tissues. The activity of the administered sample can now be determined with an accuracy of ± 3 per cent and international standardization for a number of medically useful isotopes has been achieved. Absolute methods of measurement are employed and can be applied to routine studies using reliable substandard instruments.

The absolute measurement of the sample activity of an isotope is complicated as compared to radium due to (1) its short half-life, (2) the inability to maintain standards over long periods, and (3) the major contribution or all of the dose is from β-radiation. Standardized samples of certain isotopes are now being regularly issued from the National Physical Laboratory, A.E.R.E. (Harwell).

Absolute measurements, of necessity, involve the determination of sample activity in terms of curies or fractions thereof. Since most isotopes emit one β particle per disintegration, a measurement of these particles is the simplest method in theory. The practical difficulties are numerous, however. If the disintegration scheme of the isotope is known, methods of γ-radiation measurement may be used. For a given isotope, the most suitable method depends upon the radiation it emits and frequently more than one method is employed. The authors tabulate the various absolute methods of measurement. Of these,

they have used three: (1) defined solid angle (β) Geiger counting, (2) 4π (β) scintillation counting, and (3) γ-ionization measurements.

Using the necessary corrections, emitters of high energy can be measured by the defined solid angle method which is accurately applied in measuring α emitting sources. The principal sources of error arise from (1) scattering from the source mounting, baffle, defining diaphragm, and surroundings of the jig, (2) scattering and absorption in the source itself as well as the air and window between the source and counting volume, and (3) transmission through the edges of the defining diaphragm. Of these sources of error, scatter from the defining diaphragm, that due to the finite mass of material, transmission through the diaphragm edge, and absorption and scattering through the air and mica window, required correction. The accuracy of the measurements is lessened by the magnitude of the extrapolation at low β energies and by undetermined scattering factors at high β energies. In general, the results compare satisfactorily with those obtained with 4π methods and is a procedure which can be developed with limited resources in the absence of more complicated equipment.

In 4π scintillation counting, the interdynode potential, amplifier gain and scaler resolving time are standard for each source, but the pulse discriminator is varied. The resulting curve, after necessary correction in the counting rate, is then extrapolated to zero pulse discrimination. The same technique is applied to the foil thickness and this is extrapolated to zero, thus determining the β-emission rate per gm. of solution. Limitations of this method are due to the magnitude of the extrapolations. It is most suitable for high energy β or β-γ emitters, but is of limited accuracy for β emitters of low energy.

The γ-ionization method employs the air-wall ionization chamber to measure the dosage rate at a given distance from a source. The "k" factor has been defined for many useful and important isotopes as the γ-dosage rate in roentgens per hour at 0 cm. from a point source of 1 mc. Certain limitations due to possible inaccuracies in absorption coefficients, and depending on the average energy required to form an ion pair prevent highly accurate values of disintegration rates at the present time.

A more detailed discussion of the relative accuracy of these various instruments is given but an accuracy of ± 5 per cent can be attained for most clinical uses.

Several excellent illustrations, graphs, and tables are included.—*Kenneth L. Krabbenhoft, M.D.*

Greer, Monte A., and Smith, G. Edward. Method for increasing the accuracy of the radioiodine uptake as a test for thyroid function by the use of desiccated thyroid. *J. Clin. Endocrinol. & Metabol.*, Nov., 1954, *14*, 1374–1384.

Administration of exogenous thyroid is advocated as an aid in differentiating the following groups of patients:

1. Clinical hyperthyroidism with normal I^{131} uptake.
2. Euthyroid clinically, but with elevated 24 hour per cent uptake.
3. Borderline uptake with or without clinical symptoms.

Twenty-eight thyrotoxic and 55 euthyroid patients were studied in this series. Their status was determined by subsequent course and response to treatment.

After an initial uptake, 180 mg. of U.S.P. desiccated thyroid was administered daily for one to two weeks. The majority of euthyroid patients showed a suppression of I^{131} uptake to less than 20 per cent following 180 mg. of thyroid for one week. If this does not occur, 540 mg. daily are given for one to two weeks; suppression below 20 per cent is "strongly suggestive" of euthyroidism, while the opposite result suggests hyperthyroidism. No thyrotoxic patient was reduced below 20 per cent on 540 mg. of thyroid daily, and only one was lowered to that level on 720 mg. daily.

Apparently the euthyroid gland is more readily suppressed below 20 per cent twenty-four hour uptake than is the case in hyperthyroidism.—*George Roberts, M.D.*

Hunzinger, W. A., Willenegger, H., and Meier, A. L. Blutvolumetrie mit J^{131}-Albumin nach Infusion von Plasmaersatzmitteln. (Blood volume determinations with I^{131} albumin after infusion of plasma substitutes.) *Klin. Wchnschr.*, Sept. 1, 1954, *32*, 777–780.

Blood and plasma volumes were determined with the I^{131} albumin method on 18 humans over a period of six to eight hours in order to study the dilution after infusion of plasma and a number of plasma substitutes.

The authors describe their method of making and sterilizing the I^{131} albumin solution and their system of measuring activities in liquid samples in small planchettes by means of an end-window Geiger counter tube.

Five to ten milliliters of I^{131} albumin are injected into the cubital vein in doses ranging from 100 to 200 microcuries. A needle is inserted into the cubital vein of the other arm and stays in there for the duration of the experiment, permitting easy withdrawal of blood samples at any desired time. From the activity and quantity of the injected albumin and the activity of the respective blood samples the blood volume is determined by the well known formula.

The authors calculated that for doses of 100 microcuries the total body dose received by the patient is of the order of 0.16 roentgens while the dose to

the thyroid gland is about 23 reps. An overall accuracy of 4 per cent is claimed for the blood volume determination. Plasma substitutes are infused into the same arm as the albumin about one and a half hours after the albumin injection. In the interval 3 to 4 samples are withdrawn for the determination of the blood volume. After infusion blood samples of 2.5 milliliters are withdrawn at various intervals for further blood volume determinations.

If the blood volume increasing effect is taken as a measure for the value of the plasma substitute, these substitutes can be divided into several groups: (1) A volume increasing effect which persists beyond the four hour limit of the experiment was only observed after infusion of plasma. (2) The second group, comprising colloids such as dextran, periston, oxypolyn, does not produce a volume increase beyond four hours after infusion. (3) The third group, comprising physiological saline solution and subsidon, produces only slight volume increases or none at all. A new experimental substitute, collofusion, when used in low concentrations produces effects somewhere between those observed in groups 2 and 3.—*Otto Glasser, Ph.D.*

Seidlin, S. M., Yalow, A. Aaron, and Siegel, Edward. Blood radiation dose during radioiodine therapy of metastatic thyroid carcinoma. *Radiology*, Dec., 1954, *63*, 797–813.

This study is concerned with the radiation dose delivered to the blood during the various states of I^{131} therapy for metastatic thyroid carcinoma. The influence of benign and malignant functioning thyroid tissue on the blood radiation dose was calculated from the blood I^{131} concentration and the disintegration scheme of the isotope. Approximate values for the generalized total-body radiation were estimated from the isotope concentration in blood.

Patients received oral dose of I^{131}. Determinations were made of the blood I^{131} concentration following 69 therapeutic doses to 26 patients with metastatic thyroid carcinoma. These studies were conducted for variable intervals of time, from one to thirty-five days after ingestion of the isotope. Serial blood samples were taken and the radioiodine concentration of the weighed blood samples was determined by gamma-ray counting, using a Geiger counter tube and a scaling circuit. The radiation dose delivered to the blood by the beta and gamma rays from I^{131} was calculated.

Calculations are presented by means of which the specific radiation dose (rep/100 mc.) to the blood and the total blood radiation may be computed from the area under the curve of specific blood radioiodine concentration (μc./gm./100 mc. I^{131}) vs. time. It is shown that the generalized body radiation is about 50 per cent of that received by blood.

The specific radiation dose (srd) delivered to the blood has ranged from 20 to 182 rep/100 mc., with a mean value of 56 ± 34 rep/100 mc. The maximum blood radiation due to a single dose of I^{131} was calculated to be 316 rep after administration of 208 mc.

The largest single dose of I^{131} was 208 mc. Blood radiation due to this dose was calculated to be 316 rep. The largest total amount of radioiodine administered to a patient was 2,300 mc., given over a period of two and one-half years. Except for an occasional temporary leukopenia, no untoward effects followed a single therapeutic dose of I^{131}. No permanent injury of the hematopoietic system has been observed in two patients who received total doses of 2,300 and 2,000 mc.

It was observed that the blood radioiodine concentration during the first two days after ingestion of I^{131} is lower following a radiation thyroidectomizing dose than following subsequent therapeutic doses to the same patient after thyroidectomy. However, after the initial forty-eight hours, the I^{131} concentration is usually lower if the patient no longer has a thyroid gland.—*A. W. Sommer, M.D.*

Pochin, E. Eric, Cunningham, R. M., and Hilton, Gwen. Quantitative measurements of radioiodine retention in thyroid carcinoma. *J. Clin. Endocrinol. & Metabol.*, Nov., 1954, *14*, 1300–1308.

The retention by thyroid carcinoma of successive therapeutic doses of radioactive iodine was measured in 22 patients. This was done with a counter moved along the patient's body from head to foot and shielded so as to obtain a "profile" curve of distribution of radioactivity. The time intervals between doses were from six to twenty-six weeks. It is found that the uptake of radioactive iodine decreases following a previous dose and may vary from 30 to 80 per cent of that dose. This is due to a decreasing amount of remaining tumor tissue, rather than an alteration in ability to take up I^{131}. The latter may occur if the interval between treatments is less than six weeks.

Twenty-one patients who received over 500 millicuries of I^{131} in divided doses of 100 to 150 millicuries experienced a fall in the white blood cell count following the initial dose. In 17 of these, the white blood cell count began to rise, although not to the original level, and the decrease was not sufficient to interfere with therapy. Four patients showed marrow depression which warranted a delay in treatment and was the probable cause of death in one patient. It is stated that the prospect of destroying tumor tissue with radioactive iodine outweighs the possibility of producing leukopenia.

The authors also investigated the effect on radioactive iodine turnover by thyroid tumor of thyroxine, triiodothyronine, and thyroid stimulating hormone. It is their opinion that the rapid rate of discharge of radioactive iodine by the thyroid is not decreased by these substances.—*George Roberts, M.D.*

Engfeldt, B., Björnerstedt, R., Clemedson, C.-J., and Engström, A. A preliminary study of the in vivo and in vitro uptake of Sr^{90} in bone tissue and the osseous localization of radioactive fission products from atomic explosions. *Acta orthop. Scandinav.*, 1954, *24*, 101–114.

This article is one of a series on the localization of radioisotopes in bone tissue.

A mature dog was given 1 mc. Sr^{90} intravenously, and sacrificed ten days later. Bone slices of 50 micron thickness were prepared, and first used for radioautography. A diffuse uptake of radiostrontium was shown throughout the bone, with high concentrations in the endosteal and periosteal layers, and in a few of the haversian systems.

The same bone slices were then examined microradiographically using a 30 kvp. roentgen-ray generator with a copper target. The areas of high strontium localization corresponded to regions of low mineralization.

In vitro incubation in a solution containing Sr^{90} of bone slices from a younger dog showed a similar distribution.

This localization is considered of importance from the viewpoint of the concentration of Sr^{89} and Sr^{90} in nuclear fission product.—*R. Kenneth Loeffler, M.D.*

Lang, N., Schettler, G., and Wildhack, R. Über einen Fall von "Agammaglobulinämie" und das Verhalten parenteral zugeführten radioaktiv markierten Gammaglobulins im Serum. (A case of "agammaglobulinemia" and the behavior of parenterally administered radioactive gamma-globulin in the serum.) *Klin. Wchnschr.*, Sept. 15, 1954, *32*, 856–863.

The authors report a twenty-nine year old, female patient who has had numerous infectious diseases since her tenth year. She was brought to the hospital after a severe coughing attack, with a temperature of 39.6°C. with a diagnosis of lung tuberculosis. A detailed clinical history is given. Microscopic and culture tests did not reveal any tubercle bacilli. Studies with both paper electrophoresis and the Tiselius method demonstrated the lack or temporary lack of the gamma-globulin fraction in the serum of this patient. The authors believe that this is an acquired anomaly and that no proof exists of its being congenital or hereditary.

Ten doses of gamma-globulin were injected intramuscularly and these brought the amount in the blood to the expected level but no gamma-globulin could be demonstrated electrophoretically seven days later. Similar studies were then made with I^{131} labeled gamma-globulin on this patient as well as on 4 additional control persons. These studies showed that the reduction of the radioactive gamma-globulin in all 5 persons did not follow the rules obtained thus far and that some of the conclusions which have been drawn from former studies with radioactive serum protein regarding decay and biological half-lives may have to be revised. These experiments showed furthermore that the nature of the agammaglobulinemia lies in the lack of new formation of gamma-globulins and not in an increased reduction. The rates of reduction and excretion of the gamma-globulins were the same in the patient and in the control persons. A definite concentration or reduction of the I^{131} labeled gamma-globulins in any specific organ could not be demonstrated.—*Otto Glasser, Ph.D.*

Bauer, Robert E., Moss, Irwin H., and Richardson, Aubrey D. A study of radioactive phosphorus activities in pleural effusions. *Cancer*, Sept., 1954, *7*, 852–855.

The P^{32} activity of pleural fluid is suggested as the basis for a technique to distinguish between the benign and malignant origin of the effusion. From specimens of pleural fluid and whole blood taken twenty-four hours after a dose of 100-200 microcuries of P^{32}, the relative activities were measured and expressed as the "P^{32} index"

$$= \frac{\text{cell free effusion fluid activity (cpm./ml.)}}{\text{plasma activity (cpm./ml.)}} \times 100,$$

where cpm. is count per minute (Geiger counter, Tracer-Lab. TGC-2).

In a study of 29 cases the following results were obtained:

Diagnosis	*No. of Patients*	*P^{32} Index Range*	*Average*
Chronic inflammation	8	20–42	34.1
Acute inflammation	5	49–63	56.0
Neoplasm	16	58–150	79.4

(The third group includes 2 cases who had received previous roentgen therapy which appears to produce anomalous index values and these are not included in the range of values quoted above.)

There appears to be no obvious correlation between white blood cell count, red blood cell count, or protein concentration and the "P^{32} index" (it should be noted that the table of these quantities for 16 patients does not refer wholly to the group of 16 malignant cases).

This method depends on the increased uptake of P^{32} by nucleoprotein in rapidly growing neoplastic, acute inflammatory or actively regenerating normal tissue. Elevated activities have previously been reported in leukemia (mice), gastric cancer, breast, testicular and brain tumors but simple activity determinations do not distinguish between increased metabolic activity due to benign and malignant

causes, which it is claimed is achieved by the "P^{32} index" method.—*Raymond S. Quick, B.S.*

Blocker, T. G., Jr., Levin, William C., Lewis, S. R., and Snyder, C. C. The use of radioactive sulphur labeled methionine in the study of protein catabolism in burn patients. *Ann. Surg.*, Oct., 1954, *140*, 519–523.

Methionine labeled with sulphur^{35} during biosynthesis can be used in the study of protein metabolism. Eighty to 100 microcuries of this material injected intravenously in 14 control patients established a curve for normals with a peak of activity in serum and a plateau reached in four days of about 50 per cent. These determinations were then repeated on 10 patients three to four days following burns of various degrees of severity.

The data obtained from studies on burned patients indicate that the drop from the peak level was more rapid and that the plateau was considerably lower than in normals. Furthermore, in normals, the plateau did not change appreciably in twenty-one days, whereas there was a rapid decrease in burn patients.—*George Roberts, M.D.*

CHEMOTHERAPY

Houghton, L. E., Walter, J. B., and Jones, D. E. A. The inhibition of acute x-ray damage by cortisone. *Brit. M. J.*, Dec. 4, 1954, *2*, 1313–1315.

The authors found that parenteral cortisone prevented skin ulceration in guinea pigs exposed to irradiation. A total dosage of 600 r was administered in two equal doses given forty-eight hours apart to a clipped area, 2.6 cm. in diameter, on the back of each animal, using a Philips contact therapy apparatus. Both erythema and epilation were delayed and diminished in animals receiving 10 mg. of cortisone acetate subcutaneously before irradiation and daily during the period of observation.

Nineteen controls all developed small deep ulcers by the fifty-ninth day. Only 2 of the guinea pigs given cortisone developed small ulcers, and these healed rapidly. After eighty-one days only 6 of the control group had completely healed with cicatrization, but ulceration with contraction persisted in the other control animals.

The protective action of cortisone may be due to inhibition of inflammation, although there may also be protective action during the actual exposure to radiation.—*Thomas B. Efford, M.D.*

Evans, John A., and Steinberg, Israel. Pulmonary complications of ACTH and cortisone; roentgen observations. *Radiology*, Oct., 1954, *63*, 515–524.

Serious pulmonary complications are known to occur during the course of ACTH or cortisone therapy for non-pulmonary conditions.

Two of the most significant effects of the drugs are the masking of the symptoms of the acute inflammatory process and the inhibition of the repair process. An increase in the coagulability of blood with thromboembolic complications has been associated with the use of these hormones. The sodium and water retention properties are well known.

The authors report 5 cases, 2 with tuberculosis, 1 with water retention effects, and 2 with pulmonary infarction, which conditions were attributed to therapy with the drugs. All responded satisfactorily upon withdrawal of the hormones. Pneumonitis of unknown etiology has also been observed following use of ACTH and cortisone.

The mechanism of the production of these complications is reviewed.—*E. E. Seedorf, M.D.*

Burchenal, Joseph H., Karnofsky, David A., Murphy, M. Lois, Ellison, Rose Ruth, Sykes, Marguerite P., Tan, Charlotte T. C., Mermann, Alan C., Yuceoglu, Munire, and Rhoads, C. P. Clinical evaluation of 6-mercaptopurine in the treatment of leukemia. *Am. J. M. Sc.*, Oct., 1954, *228*, 371–377.

A clinical evaluation of the recently synthesized 6-mercaptopurine in the management of leukemia and related diseases is given. This drug, a purine antagonist, may be categorized with the folic acid antagonist, aminopterin, in that both are antimetabolites. However, they apparently act through different mechanisms, and no cross resistance is thus afforded.

The new drug was administered to 269 patients, of whom 140 had acute leukemia, 8 subacute, 18 chronic myelocytic, and 4 chronic lymphocytic leukemia. The usual daily dose in children and adults was 2.5 mg./kg. by mouth which produced few toxic manifestations. The antileukemic effect of mercaptopurine generally did not become evident until after three to eight weeks of continuous therapy. The drug was found to have no practical value in chronic lymphocytic leukemia, Hodgkin's disease, or any of the metastatic carcinomas studied. Satisfactory remissions in 11 out of 12 patients with an early stage of chronic myelocytic leukemia were obtained, but relapses occurred unless maintenance therapy was provided.

The greatest therapeutic effect of mercaptopurine appeared to be in children with acute leukemia, 41 out of 87 of whom had good clinical and hematological remissions lasting from one to ten months. Adults with similar disease did not respond nearly as well. Many cases still responded to aminopterin after the beneficial effects of mercaptopurine had waned.

The authors feel that mercaptopurine adds an-

other type of antileukemic agent to the armamentarium of the clinician. They believe that in acute leukemias, the antimetabolites (aminopterin and mercaptopurine) should be the main reliance of the chemotherapist, with hormones (cortisone and ACTH) being reserved for the emergency situations where the disease has become resistant to the antimetabolites or where there is not sufficient time for use of these slower acting drugs. They found that sequential use of the various drugs gave more satisfactory results than any type of combination therapy.—*Arch H. Hall, M.D.*

MISCELLANEOUS

Hurst, G. S., and Ritchie, R. H. Fast neutron dosimetry. *Radiology*, June, 1953, *60*, 864–869.

Neutrons do not ionize directly, but by various reactions with tissue they produce particles which do ionize. In the case of fast neutrons the important reactions are the elastic collisions with hydrogen, carbon, nitrogen, and oxygen atoms. The recoil nuclei are charged and spend the energy gained from the neutron by ionization and excitation of the tissue atoms. Thus, it is important to measure the amount of energy imparted to a gram of tissue. Accordingly, the unit accepted for measuring the tissue dose of fast neutrons is the roentgen equivalent physical (rep), which is the amount of radiation needed to dissipate 93 ergs per gram of soft tissue.

Recent work done on fast neutron dosimetry by the Health Physics Division of the Oak Ridge National Laboratory is summarized. Two methods have been developed specifically for measuring the dose due to fast neutrons in the presence of gamma radiation.

The first method involves the use of a counter so designed that its count rate dependence on energy is the same as the variation of the dose with energy. The amount of energy that is given to the atoms in a gram of tissue can be calculated if the various cross sections are known, and if one assumes that the scattering of all the atoms is isotropic in the center of the mass system. Tissue dose may be measured by simply counting the number of pulses produced in a carefully designed proportional counter. Gamma discrimination is accomplished by setting the bias on the electronic circuit greater than the largest gamma pulses.

The second method requires the use of an instrument which is more complicated but is not directional. This instrument uses a proportional counter which is filled with ethylene and is lined with a layer of polyethylene whose thickness is greater than the range of the most energetic protons. A measure of total ionization produced in the cavity is proportional to the energy dissipated per gram of ethylene. The ratio of ethylene dose to tissue dose is essentially independent of neutron energy.—*Arno W. Sommer, M.D.*

Whitcher, S. L., and Todd, Norman. The x-ray absorption coefficients for a borosilicate glass. *Radiology*, July, 1953, *61*, 103–105.

The authors present the calculated absorption coefficients of a commonly used borosilicate glass (pyrex), which were derived by means of the coefficients of the component elements of the glass, using the linear combination formula first given by Walter. The results compare favorably with available experimental data.

It would be possible to calculate similarly the characteristics of other types of glass, if the composition were known.

The calculation is explained, and tables are shown, including the mass and linear coefficients for the type of glass mentioned, in the energy range 10–500 kev., and a breakdown of the linear coefficient into its components.—*Lynne J. Taylor, M.D.*

Wang, Theodore J. Calibration of therapeutic x-ray generators. *Radiology*, June, 1953, *60*, 885–894.

The calibration of a therapeutic roentgen-ray generator involves both physical and clinical considerations. Only the physical aspects are treated in this paper. The actual physical calibration process is a relatively simple matter, but certain precautions are necessary for reasonable accuracy.

Among ionization instruments which are employed for this purpose the convenient Victoreen condenser r-meter is used so frequently that it has become almost a secondary standard. The author gives detailed information which will enable the user of this type of r-meter to obtain accurate calibration. —*Arno W. Sommer, M.D.*

Abel, Martin S. Body-section radiography with an ultra-fine focal spot tube utilizing variable magnification for plane selectivity. *Radiology*, Oct., 1954, *63*, 508–514.

A method and apparatus for laminagraphy are described. Simultaneous movement of a very fine focal spot tube and film along the same axis, perpendicular to the selected plane is utilized. The resultant is a magnified projection wherein the selected plane is in focus and structures in other planes are blurred by a continually varying rate of magnification during the exposure. The method yields a thick section laminagram with clarity fading more rapidly in the tube direction than in the film direction. Normal relationships are maintained, and no fictitious shadows are introduced.

The roentgen tube and film move toward each other during the exposure along the same axis. If the tube and film move at equal speeds, the distances are pre-set so that the selected plane is midway between focal spot and film. This level, then, remains

midway at all times during the exposure and is magnified at all times by a linear factor of two. All other planes are magnified at a variable rate and are blurred to a variable degree.—*A. W. Sommer, M.D.*

Ponseti, Ignacio V., with the assistance of Shepard, Robert S. Lesions of the skeleton and of other mesodermal tissues in rats fed sweet-pea (*Lathyrus odoratus*) seeds. *J. Bone & Joint Surg.*, Oct., 1954, *36-A*, 1031–1058.

Diets containing *Lathyrus odoratus* seed, 50 per cent, were fed to rats which produced a hitherto unrecognized lesion in the epiphyseal plates. These lesions were very wide, the cartilage matrix appeared to loose cohesion, and the cartilage cells were grouped in clusters. The same diets produced loosening and detachments of the tendinous and ligamentous insertions. Because of these two lesions, occurring independently or together, skeletal changes developed as follows: epiphyseal slippings, metaphyseal fibrous defects, kyphoscoliosis, thoracic deformities, detachments of the tibial tuberosity, subluxations and dislocations of the shoulder, diastasis of the sacroiliac joints, degeneration of the intervertebral discs, disc herniations, Legg-Perthes-like disease of the femoral head and valgus of the forepaws. In practically all the experimental rats there were extensive areas of periosteal new-bone formation following detachment of the periosteum. Degenerative arthritis developed in rats fed the experimental diets for several months. Two lesions developed concomitantly—degeneration of the joint cartilage and loosening of the capsular and ligamentous insertions. Bone lesions resembling Paget's disease were observed in small groups of older rats. Dissecting aneurysms of the aorta and abdominal and inguinal hernias were seen in many rats. The collagen fibers appeared to be normal on electron microscopic examination. The authors surmise that all these lesions are due to defective formation or excessive destruction of the chondroitin sulphate of the ground substance.

Observations made in the experimental animals during the course of these studies seemed to be of especial interest: A high oxygen consumption was found in the muscles; there was partial arrest of spermatogenesis and giant cell formation in the testes; and there was resorption of the fetus in pregnant rats fed the experimental diet. All these findings are known to occur in animals fed vitamin E-deficient diets. The authors have had a group of rats on vitamin E-deficient diets for three months but thus far they have not observed any skeletal lesions in the roentgenograms. It has not been proved that vitamin E is connected with the synthesis of chondroitin-sulphuric acid nor that the active substance of *Lathyrus odoratus* is a vitamin E antagonist.

The possible relationship between the lesions shown in rats in this experimental study and similar lesions in humans is a matter for further study. Such relationship is the subject of discussion in the article. Among the lesions mentioned are so-called idiopathic scoliosis, juvenile or adolescent kyphosis, slipping and diastasis of the sacroiliac joints, Legg-Perthes disease, slipping of the upper femoral epiphysis, painful detachment and fragmentation of the tibial tuberosity, degenerative arthritis and Paget's disease. It is suggested that in Paget's disease the underlying cause may be a defect of the mucopolysaccharides present in the cement substance of the bone. The lesion of periosteal bone formation seen in the experimental rats is quite similar to that seen in infantile cortical hyperostosis.—*Ralph S. Bromer, M.D.*

Furth, Jacob, Upton, Arthur C., Christenberry, Kenneth W., Benedict, Walter H., and Moshman, Jack. Some late effects in mice of ionizing radiation from an experimental nuclear detonation. *Radiology*, Oct., 1954, *63*, 562–570.

Exposure of a large population of mice to nuclear detonation under controlled conditions confirmed earlier findings on the late effects of ionizing radiation and led to the discovery of additional late effects.

The non-neoplastic changes, such as cataract, nephrosclerosis, and atrophy of the iris, develop and progress in direct proportion to the dose. They may result from local radiation damage of these organs. Certain neoplasms, however, such as those of the ovary, pituitary gland, and breast, may be induced by a[illegible]nbalance" of the normal physiologic regulatory mechanism. Development of ovarian tumors appears to be related to a disturbance of the ovary-pituitary relation. Adrenal-pituitary "imbalance" may be responsible for pituitary tumors. Breast tumors are attributed to deranged secretions of gonadal hormones.

The sequence of events is precisely reproducible, yet the exact mechanisms by which these changes are initiated and realized are unknown.

The total number of mice exposed to ionizing radiations in this investigation was about 4,000. The cause of death in most of the animals which survived for thirty days remains obscure. Both delayed mortality and longevity are related to the dose of radiation. A significant shortening of the life span resulted even from doses well beneath the threshold for acute lethality. This reduction of longevity was caused mainly by degenerative and neoplastic disease induced or exaggerated by irradiation.—*A. W. Sommer, M.D.*

Bruce, W. R., and Johns, H. E. Investigation of grid fields with a miniature ionization chamber. *J. Canad. A. Radiologists*, Sept., 1954, *5*, 29–32.

Roentgen therapy through grids is more effective than conventional roentgen therapy in some instances but creates difficult problems in depth dose determinations. Densitometric measurements have provided qualitative information relative to the depth dose. Condenser chambers in a presdwood phantom were used but being of the same diameter as the aperture gave no indication of variations in dose across the opening.

Loevenger found that standard depth dose tables can be used to compute grid depth doses essentially but the drop in intensity at the edge of the field and the shape of the maxima or minima cannot be expressed with this method. The authors plotted scatter as a function of the radius from the back scatter factors and depth dose figures of Johns and calculated theoretical depth dose tables.

A small ionization chamber was then used to study the degree of inhomogeneity in dose superficially and at a depth beneath a grid. This chamber had an air wall cap with an internal diameter of 1.5 mm. and a length of 6 mm. It was made wavelength independent by employing an aquadag coated central aluminum wire which passed through solid polystyrene to the preamplifier. To obviate error in measuring depth dose along the axis a flat, shallow chamber 1 mm. deep and 3 mm. in diameter was used.

The grid utilized in making calculations for beams of HVL. 1.0, 2.0, and 3.0 mm. Cu had 1 cm. diameter holes every 1.4 cm., giving 40 per cent transmission. Square fields of 50 cm.^{2}, 100 cm.^{2}, 225 cm.^{2}, and 440 cm.^{2}, each including an integral number of holes were used. The depth dose for four different positions beneath the grid is given, *i.e.*, center of opening, and center of shielded area midway between four openings in the middle and at the edge of the field for both positions. Experimental results using a grid with openings of 1.5 cm. by 1.5 cm. and employing a beam of HVL. 1.5 mm. Cu are shown by graph and isodose curves. These agree with the theoretical calculations above for the various conditions studied. Loevenger's method, failing to allow for non-uniform scattering, gives doses which are too high for the edges of the field and shielded areas as well as doses which are too low beneath the central openings. These errors are considered to be clinically insignificant, however, and his method is satisfactory for evaluating dose distributions near the central axis.—*Kenneth L. Krabbenhoft, M.D.*

Schoen, D., and Magnus, H. E. Bewegungsbestrahlung durch Bleisieb. (Moving field irradiation through a lead grid.) *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, Nov., 1954, *81*, 670–679.

There are four methods for obtaining increased radiation dosages at the site of deep-seated tumors: (1) distribution of radiation doses over longer times as in fractionation and protraction, (2) distribution of dose concentration within volume or area using the grid method or radium implantation, (3) thinning of radiation intensity by increasing the irradiated area, using moving field irradiation, (4) thinning of ionization density in irradiated volume by using ultra-hard radiation.

While therapeutic possibilities are definitely increased by combining fractionation and protraction with the other methods, the combination of moving field irradiation with the grid method has not yet been investigated. This the authors set out to do, calling the method "small volume moving field irradiation" in contrast to the generally used "large volume moving field irradiation." They used the pendulum unit of the C. H. F. Müller Co., with 200 kv., 0.7 mm. copper half-value layer and an output of 100 roentgens per minute at 50 cm. focal skin distance. Measurements were made on a paraffin phantom which had the shape of the human abdomen. Various ionization chambers were used but on account of its smallness (20 cubic millimeters) the chamber of the Bomke dosimeter was especially well suited for these measurements. It was smaller than the holes (9 mm. diameter) of the lead rubber grid used. These holes were arranged in parallel rows, 2 cm. apart. The lead equivalence of the grid thickness was 2.5 mm.

The authors found that by combining grid therapy with moving field therapy the effect of the reduction of the irradiated area is compensated by a gain in biological tolerance. Since the surface dose is reduced no significant amount of scattered radiation is produced at small angles of the pendulum movement. This also applies to the dose which the healthy tissue receives and the reduction is of the order of 15 per cent in an example discussed by the authors. The relative tumor dose is consequently more favorable even when compared with large volume pendulum therapy. The biological effects produced by the combined grid and pendulum methods cannot be calculated.—*Otto Glasser, Ph.D.*

Rigler, Leo G., and Watson, John C. A combination film changer for rapid or conventional radiography. *Radiology*, Nov., 1954, *63*, 706–715.

Previously, the authors described the preparation of a new experimental rapid film-changing device. Since then, a practical unit was constructed and tested in clinical roentgenography.

With a speed of up to five exposures per second, it can be used for cardiovascular and cerebrovascular roentgenographic procedures as well as conventional roentgenography. Such flexible employment is possible because of two unique features: (1) The roentgen-ray control unit leads the exposure, allowing rapid intermittent single exposures or multiple exposures on one film. The film-changing speed can

be altered during a procedure. (2) A Helex cutting blade rapidly separates each film at the end of exposure, allowing processing of films at any time.

The device is composed of three main parts: An operational unit comprising the major mechanism o the film advancing process, a supply magazine utilizing roll film, and a film receiver into which the exposed separated films go in a sequential manner. It can be adapted to any roentgenographic table, replacing the conventional Bucky diaphragm, and may be mounted on rails so that it can be brought out to the end of the table to facilitate unloading and loading of film. Since control of the film is positive at all times, the unit can operate in any plane. The mechanical and operational details with many illustrations are provided.

Several problems, such as providing good screen contact, avoiding film abrasion, and the tendency to accumulate static have been eliminated. Although the present unit allows only an exposure area of 11 by 11 inches, there is no reason why future units can not be designed to use other film sizes. A reciprocating Bucky diaphragm could be mounted to ride above the unit.

Although thorough clinical trial has not yet been possible, the authors' experience to date indicates that the unit is practical, and they have employed it is angiocardiography, cerebral angiography, splenoportography, and in stomach, gallbladder, and skeletal work. It eliminates the necessity of changing individual cassettes, and is of especial value when multiple exposures are to be made of any anatomical part.—*C. L. Stevenson, M.D.*

Shellabarger, C. J., and Godwin, John T. Studies on the thyroidal uptake of astatine in the rat. *J. Clin. Endocrinol. & Metabol.*, Oct., 1954, *14*, 1149–1160.

It is known that all the halogens, with the exception of fluorine and chlorine are concentrated by the thyroid and this article reports studies with the heaviest of the group, astatine, in the rat and the effect of thiouracil on uptake. (In table 2 in the paper, the end product of At^{210} should be Pb^{206}.) The activity of the thyroid, after removal, and of the whole blood or serum was measured, and autoradiographs taken of tissue sections, a duplicate series being made with I^{131}.

The concentration of astatine, while greater than would be expected by simple diffusion, is less than that of I^{131} and the ratio increases with time after administration; when measured by the thyroid-blood ratio the uptake appears to be greater for astatine than for iodine in the first hour. The usual methods failed to separate the thyroxine and protein bound component from inorganic astatine. In contrast to iodine, previous thiouracil treatment produces a marked increase in thyroid uptake, and the autoradiographs show clusters of alpha tracks ("stars") which are not found in the absence of thiouracil. It is suggested that thiouracil may cause an aggregation of astatine atoms or biological accumulations may occur but available information on this point is still inadequate.

The uptake of I^{131} is unaltered by previous administration of astatine, indicating that there is no general modification in the ability to concentrate halogens as a result of the alpha radiation. It appears unlikely that astatine is organically bound in the thyroid in the absence of evidence that this occurs for any other halogens apart from iodine and present autoradiographs do not permit the measurement of the distribution of alpha particles between colloid and peripheral cells.—*Raymond S. Quick, B.S.*

Hamilton, Joseph G., Durbin, Patricia W., and Parrott, Marshall. The accumulation and destructive action of astatine^{211} (eka-iodine) in the thyroid gland of rats and monkeys. *J. Clin. Endocrinol. & Metabol.*, Oct., 1954, *14*, 1161–1178.

The modifications in the growth pattern and histopathological changes produced by astatine^{211}, the radioactive and heaviest halogen (85), at high dosage levels in rats (Sprague-Dawley females) and *rhesus* monkeys are described and compared, for rats, with the corresponding changes produced by I^{131}.

With both astatine and iodine the growth curves for the rat, expressed as per cent of the weights of control animals, show an initial rapid drop followed by a partial recovery, which is attributed to acute radiation injury and a subsequent progressive deficiency correlated with endocrine disturbances accompanying the decrease in thyroid hormone. Experimental differentiation between these two effects is difficult and it is noted that rats in which the thyroids had been completely protected by the prior administration of stable iodine died considerably earlier than rats with unprotected thyroids. In the monkey, no obvious acute radiation effect is evident at the dosages employed but a similar chronic growth defect is again ascribed to endocrine changes.

Microscopically, there is considerable difference between the effects of astatine and iodine in the rat thyroid at both the acute and chronic stages which is attributed to the great variation in range and ion density between the beta particles of iodine and the high energy alpha particles of astatine and, also, there may be a minor effect due to the gamma rays associated with the I^{131}. Severe thyroid injury occurs earlier with iodine followed by extensive fibrosis and also widespread damage to parathyroid and other peritracheal structures which is absent following even complete destruction of the thyroid by astatine. In general, the damage associated with I^{131} is uniform and complete; with astatine, localized and irregular. Atypical epithelial cells in the peritracheal

region of a monkey are shown to accumulate iodine two years after the complete destruction of the thyroid by astatine.

The chemistry of astatine is known to be complex and theories of the metabolism are discussed briefly. Following single doses of astatine mammary tumors occurred in 11 of 30 rats, the first being observed after 135 days, whereas in 20 controls no tumors were found after 325 days; the average age of incidence for spontaneous tumors in this strain is 460 days. There are occasional pulmonary metastases and the incidence appears to be independent of dose, suggesting that they are induced by endocrine disturbances and not as a direct result of radiation. —*Raymond S. Quick, B.S.*

Duff, G. Lyman, McMillan, Gardner C., and Lautsch, Elizabeth V. The uptake of colloidal thorium dioxide by the arterial lesions of cholesterol atherosclerosis in the rabbit; its significance in relation to pathogenesis. *Am. J. Path.*, Sept.-Oct., 1954, *30*, 941–955.

The theory that the nutrition of the intima of arterial walls is provided by fluid derived from plasma which permeates to the intima has generally been accepted. It has also been assumed that the lipids which accumulate in the intima in atherosclerosis are derived in the same manner.

The authors have studied these theories by the use of identifiable colloidal material and its entry into experimentally produced atherosclerotic lesions as compared to introduction into animals with normal arteries.

Colloidal thorium dioxide was injected intravenously into normal rabbits and into rabbits previously fed cholesterol for one week to three months. Microscopic examination was done for presence of the characteristic granular aggregates of thorium dioxide in killed animal specimens.

The authors found no evidence of thorium in normal arterial endothelium or intima of normal rabbits nor in those tissues of normal appearance which were situated between atherosclerotic lesions in cholesterol fed rabbits. There was evidence of rapid and consistent thorium accumulation in some of the endothelial cells and in superficially located foam cells which constituted the major cells of atherosclerotic lesions. The authors thus felt that thorium dioxide entered through the endothelial lining to the intima from the arterial lumen and not from the vasa vasorum. This would substantiate the concept of nutrition of the intima by perfusion of fluid from plasma as well as the assumption that colloidal substances, such as lipids, enter the intima from the lumen to accumulate in atherosclerotic lesions.

Study of the circulating blood showed no cells transporting thorium which would seem to deny the hypotheses that foam cells in atherosclerotic lesions originate in the reticuloendothelial system and migrate into the blood to invade the intima.

They conclude that the reaction which allows endothelial cells to accumulate thorium during cholesterol feedings is non-specific and that this change in biologic properties occurs as early as the first appearance of lipid deposits in the intima.—*P. C. Harding, M.D.*

Daniel, P. M., Prichard, Marjorie M. L., and Ward-McQuaid, J. N. An angiographic study of the renal circulation in experimental hypertension in the dog. *Brit. J. Surg.*, Sept., 1954, *42*, 212–216.

The object of this study was to note whether any change in the renal circulation was present in experimental hypertension. Angiograms were made on 6 animals, from eight to twenty-one days after application of a Goldblatt clamp to the main renal artery.

Nearly all the animals had a rise of blood pressure. Some dogs suffered from fits and died from hypertensive uremia after a few days. The others remained in good health, although two became uremic later, one of these going blind.

The animal with no rise of blood pressure showed a normal renal circulation with a good perfusion of both cortex and medulla and a renal circulation time of 2.5 seconds. The angiographic picture and the time relations of the passage of the contrast medium through the cortical and medullary circulations were remarkably similar to those seen in normal dogs. Three of the animals whose blood pressure had risen also showed an apparently normal renal circulation. However, in the animal with a blood-urea level of 500 mg. per 100 ml., the renal circulation was greatly diminished, both the cortex and the medulla being affected, and the circulation time being longer than normal.

Angiograms were also made on 6 further animals between ten and forty-two days after application of a Goldblatt clamp. In 5 of these dogs the clamp had been applied to one of the two primary branches of the renal artery, and in 1 animal it had been placed on one of the two more or less equal-sized renal arteries found to be present. Four of these animals had a rise of blood pressure of 30 to 40 mm. Hg above their normal levels. In the other 2, the pressure had fallen to normal and to 20 mm. Hg above normal respectively by the time the angiograms were made. In all these animals the circulation through that part of the kidney supplied by the clamped artery was reduced; in some instances it was virtually absent. At postmortem examination this part of the kidney was in most animals found to be atrophied or even infarcted.

In 7 animals the blood pressure in the renal artery on either side of the Goldblatt clamp was determined, without any fall in the systemic blood pressure

having occurred as a result of the operative exposure.

In the four kidneys injected with Berlin blue no abnormality was seen, in the distribution of the mass either in the "clamped" or "unclamped" parts of the kidney. The blue was found in glomeruli throughout the cortex, as well as in the vessels of the medulla, even in those parts of the kidney which had become atrophic.

Exteriorization (explanting) of the kidney, which made it possible to obtain renal angiograms of good definition with minimal disturbance of the animal, did not appear to affect the general health of the dog, its renal circulation, or its systemic blood pressure.

Angiographically, the only animals which showed any abnormality were those which had developed uremia. In these the circulation through both the cortex and the medulla was noticeably impaired.

Thus this series of 12 dogs provided no evidence of a substantial change in the relative distribution of the intrarenal blood flow between the cortex and the medulla. These findings agree with the normal renal clearances which have been reported in dogs with experimental hypertension by several authors. —*Stephen N. Tager, M.D.*

Sapeika, N. Lead EDTA complex; further radiographic studies. *South African M. J.*, Nov. 6, 1954, *28*, 953–956.

The author has experimentally demonstrated the value of the lead complex of ethylenediamine tetraacetic acid (lead EDTA) as a water-soluble contrast medium for oral and parenteral administration.

The present study deals with other preparations of the opaque medium which would travel more slowly along the digestive tract and the use of the aqueous solution intravenously for study of the urinary tract. The latter preparation was compared with 50 per cent diodone, the former with an aqueous solution of lead EDTA and with a standard suspension of barium sulfate.

The experimental animals, adult albino rats, showed transitory fall in blood pressure with the use of 1 ml. per kg. of concentrated solution (50 per cent) injected intravenously. All other preparations were well tolerated and excellent deliniation of the urinary and gastrointestinal tracts was obtained. With aqueous solutions orally the entire gastrointestinal tract was rapidly visualized. The more viscous suspension of methylcellulose bentonite magma moves more slowly and gives a more uniform shadow than the barium sulfate suspension.—*Arthur B. Smith, M.D.*

Arnulf, G., Bénichoux, R., Losson, and Morin, G. Documents expérimentaux et cliniques sur la lymphographie. (Experimental and clinical results with lymphography.) *Presse méd.*, Nov. 24, 1954, *62*, 1631–1633.

In dogs, it is possible to outline the lymphatics by injecting radiopaque material in the cellular tissues at the extremity of the paw. The most effective radiopaque material was found to be thorotrast; 4–5 cc. permitted visualization of the lymphatic network quite fully. The primary lymphatics are seen in five to ten minutes and the popliteal lymph nodes in ten minutes. These lymph nodes remain visible for twenty-four hours while the shadows of the lymphatics disappear in fifteen to thirty minutes. Some of the experimental data obtained by this method include: (1) thorotrast is arrested following total ligature of the lymphatics; (2) removal of the popliteal lymph node does not completely stop lymphatic drainage (thorotrast accumulates where the lymph nodes had been and then drains to adjacent lymph nodes; (3) ligature of the large venous trunk does not interfere with the lymphatic pattern nor with the rapidity with which it is filled.

Similar injections in man were unsuccessful indicating that the behavior of thorotrast injected in the cellular tissues was quite different from that in the dog. In man, a successful method has been the following: (1) inject 2.5 cc. of a sterilized 11 per cent solution of "patent blue violet." The injection is made subcutaneously into the interdigital spaces of the hand or foot. The member is massaged and moved actively for a few minutes; (2) at a subsequent period a skin incision is made on the back of the forearm or foot and the colored lymphatics are located; (3) through a fine needle, 7–8 cc. of diodone 70 per cent is injected into one of the colored lymphatics. Lymphatic drainage is much slower than venous blood flow and therefore roentgenograms must be made at intervals of several minutes.—*Marcy L. Sussman, M.D.*

Parker, H. M. Symposium on radiation units. Radiation units and radiation instruments. *Radiology*, Nov., 1954, *63*, 629–636.

The unit of quantity of any phenomenon of science is often some observable effect of the particular agent. In the early days of radiology, many of the newly discovered effects of ionizing radiation served as measuring methods. One of the most important effects observed and used in measurement was that of the ionization of gases. The roentgen was based on this measurement. The early instrument used was the familiar free air chamber, and later the thimble chamber, which gave comparable results, was introduced.

A different approach to dosimetry was taken in the 1930s with the statement of the Bragg-Gray principle. This provided a method of determining the energy absorption of radiation in a medium in terms of the physical measurement of the ionization in a very small gas-filled cavity in the medium at the locus of interest. This led to a new kind of instrumentation, a thimble chamber in which the wall

material was the important medium and the nature of the ionized gas was subordinate. Two fundamental improvements were involved. It was no longer necessary to restrict primary measurements to narrow beams, which were difficult to define at high energies, and secondly, the revised method could handle radiation incident on the receptor from all directions.

The immediate physical events that take place when radiation is incident on tissue and the subsequent clinical reactions are well known. The intermediate processes are not well understood, and until they are, it has been generally accepted that radiation dose shall be specified in terms of energy absorption per gram of tissue at the locus of interest. At the recent International Congress of Radiology, it was agreed to avoid confusion between the various reps and other equivalents, by defining an absorbed dose of any ionizing radiation as the amount of energy imparted to matter by ionizing particles per unit mass of irradiated material at the place of interest. This amount is expressed in "rads," a rad being the unit of absorbed dose and is 100 ergs per gram.

Instrumentation methods may be divided into three groups. Under the first group may be listed those methods which yield the absorbed dose. This group is made up of four classes of measurement, depending upon the receptor and the method of measurement. In the second group are included those basic secondary methods which yield dose in roentgens, and include the open air chamber, the pressure plate chamber, and the air equivalent Bragg-Gray chamber. The third group includes the nonbasic secondary methods which require calibration against a primary method, and include, among others, Geiger counters, ion chambers, film, chemical dosimeters, etc.

The author discusses appropriate methods and units for measurement of particulate radiations and mixed exposures, and mentions special cases in which energy absorption can be derived from first principles in isotope irradiation. The alternative approach by the physical method of conversion of intensity to dose is indicated.—*A. Ralph Watson, M.D.*

Focht, Elizabeth F. Symposium on radiation units. Surface dose. *Radiology*, Nov., 1954, *63*, 637–645.

The measurement of tissue doses of ionizing radiations is in itself rather complicated, but to these difficulties, the surface dose adds its own problems. Due to the difficulty of measuring the roentgen at high energies, and since roentgens have no simple relation to the entity which is more directly related to the biological effect (*i.e.*, the energy absorbed), it is obvious that a unit of absorbed dose would be best for specification of surface dose above 2 mev.

The author describes a method of determination of absorbed dose in rads by calculations made from the results obtained by ionization studies carried out with the extrapolation chamber. She points out that to be of biological relevance, the surface dose should be specified throughout the region in which the cells of interest lie. If the surface dose curves are very steep, this may be done by taking the integral dose over the critical depth interval.

Factors which may have to be taken into consideration in correlating biologic effect with dose are discussed. Among the factors noted are the half-value layer, the possible greater absorption of materials of higher atomic number in the skin, effect of Compton electrons, specific ionization, and time factor.—*A. Ralph Watson, M.D.*